PB80-209539

Proceedings of Marine Environmental Implications of Offshore Drilling in the Eastern Gulf of Mexico. Conference/Workshops Held at St. Petersburg, FL on Jan. 31, Feb. 1, 2, 1974

State Univ. System of Florida Inst. of
Oceanography, St Petersburg

Prepared for

Bureau of Land Management
Washington, DC

Mar 74

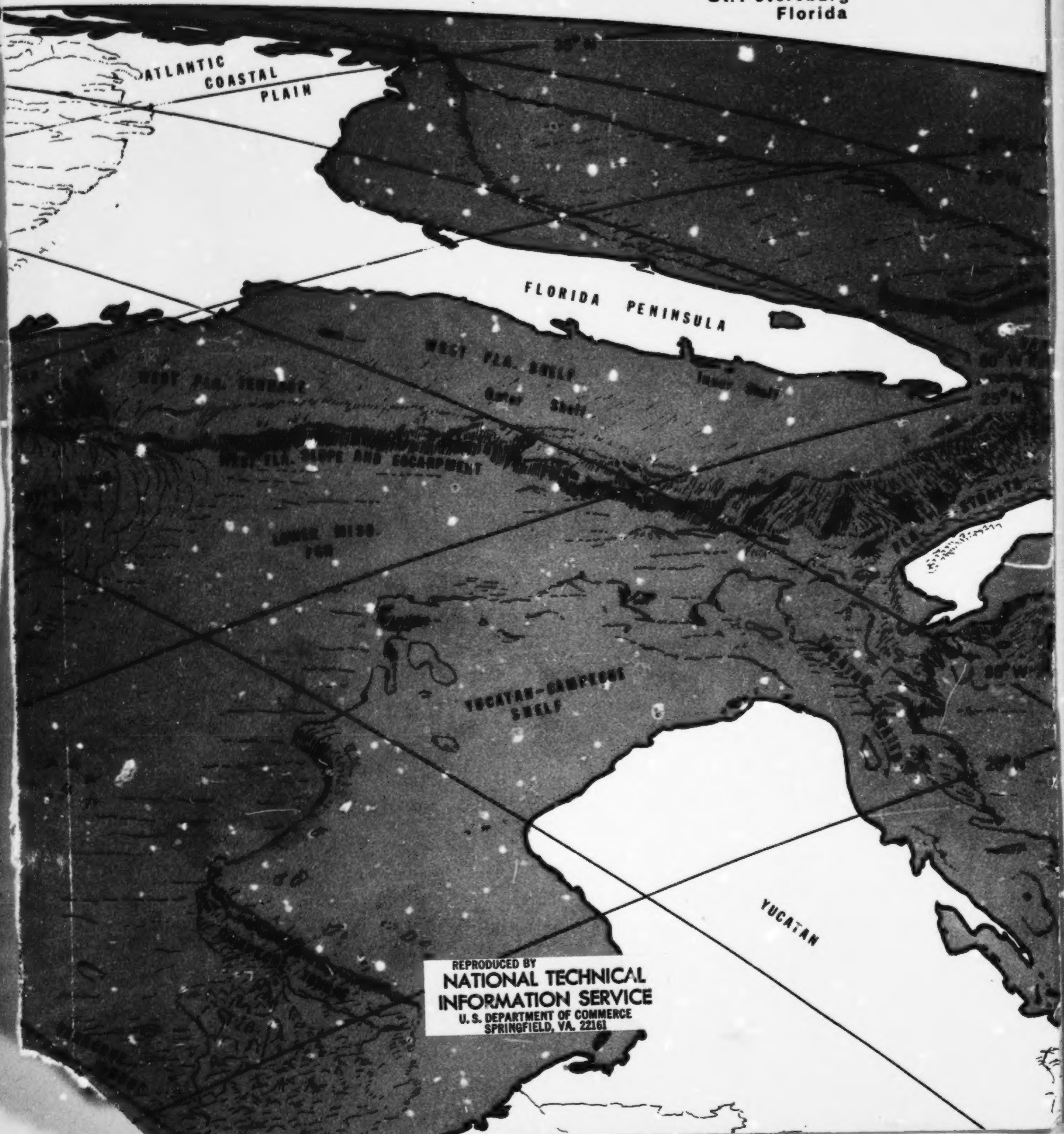
U.S. Department of Commerce
National Technical Information Service
NTIS

PB80-209539

PROCEEDINGS OF

MARINE ENVIRONMENTAL IMPLICATIONS OF OFFSHORE DRILLING EASTERN GULF OF MEXICO : 1974

CONFERENCE / WORKSHOPS
January 31, February 1 & 2, 1974
St. Petersburg
Florida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FLORIDA PENINSULA
WEST FLA. SHELF
Inner Shelf
Outer Shelf
WEST FLA. TERRACE
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SPRINGFIELD, VA. 22161

50272-101

REPORT DOCUMENTATION PAGE

1. REPORT NO. BLM/YM/ES-74/4

2.

3. Recipient's Accession No. PB 80 209539

4. Title and Subtitle
Proceedings of Marine Environmental Implications of Offshore Drilling - Eastern Gulf of Mexico: 1974

5. Report Date March 1974

6.

7. Author(s)

8. Performing Organization Rept. No.

9. Performing Organization Name and Address
State University System of Florida Institute of Oceanography
St. Petersburg, Florida

10. Project/Task/Work Unit No.

11. Contract(C) or Grant(G) No.
(C) 08550-CT4-5
(G)

12. Sponsoring Organization Name and Address
U.S. Department of the Interior
Bureau of Land Management
18th & C Streets, NW
Washington, D.C. 20240

13. Type of Report & Period Covered Final Report 1974

14.

15. Supplementary Notes

16. Abstract (Limit: 200 words)

The impending Outer Continental Shelf (OCS) oil exploration and production activities in the eastern Gulf of Mexico have catalized the interest and concern of a significant cross section of individuals and organizations. The conference/workshops were planned and held to properly define by priority the critical research and/or information needs in the subject area, to discuss the development of a scientifically sound and relevant interdisciplinary program and to identify the persons to implement same. The conference/workshop sessions were attended by 352 persons; participants came from many parts of the United States.

17. Document Analysis a. Descriptors

Oceanography
Marine Environments
Geology
Meteorology
Physical Oceanography
Marine Biology
Sedimentation

b. Identifiers/Open-Ended Terms

Mississippi, Alabama, Florida (MAFLA)
Baseline
Hydrocarbons
Florida Middle Ground

c. COSATI Field/Group

18. Availability Statement
RELEASE UNLIMITED

19. Security Class (This Report) UNCLASSIFIED

20. Security Class (This Page) UNCLASSIFIED

21. No. of Pages

22. Price

(See ANSI-Z39.18)

See Instructions on Reverse

OPTIONAL FORM 272 (4-77)
(Formerly NTIS-35)
Department of Commerce

PROCEEDINGS

OF

MARINE ENVIRONMENTAL IMPLICATIONS OF OFFSHORE DRILLING IN THE EASTERN GULF OF MEXICO

CONFERENCE/WORKSHOPS
January 31, February 1, 2, 1974

Supported by
State University System of Florida
Bureau of Land Management
Environmental Protection Agency
American Petroleum Institute

Hosted by
University of South Florida
Department of Marine Science
St. Petersburg Campus, Bayboro Harbor
St. Petersburg, Florida

and

Florida Department of Natural Resources
Marine Research Laboratory
St. Petersburg, Florida

Coordinated and Administered
through
State University System of Florida Institute of Oceanography (SUSIO)
St. Petersburg, Florida
Florida Coastal Coordinating Council (FCCC)
Florida Interinstitutional Committee on Oceanography (FICO)

Edited by Robert E. Smith

State University System of Florida Institute of Oceanography
St. Petersburg, Florida
March, 1974
74 - 4

State University System of Florida
Institute of Oceanography
830 First Street South
St. Petersburg, Florida 33701

Preface

The impending Outer Continental Shelf (OCS) oil exploration and production activities in the eastern Gulf of Mexico have catalyzed the interest and concern of a significant cross section of individuals and organizations. The conference/workshops were planned and held to properly define by priority the critical research and/or information needs in the subject area, to discuss the development of a scientifically sound and relevant interdisciplinary program and to identify the persons to implement same.

The conference/workshop sessions were attended by 352 persons (Appendix V); participants came from many parts of the United States (Appendix VI).

The prompt production of these proceedings was coordinated and supervised by Alma N. Horn, State University System of Florida Institute of Oceanography.

The technical editing was done by Christopher L. Combs, State University System of Florida Institute of Oceanography. Gratefully acknowledged is the editorial expertise and proofreading done by Mrs. Kermit S. Combs, assisted by Miss Karilyn Bouson. Transcription of manuscripts into press-ready copy was patiently done in record-breaking time by Mrs. Arlene Lyon and Mrs. Marilee Stockwell.

The cover design was adapted, with permission, from a drawing by Ellyn Jones under supervision of H. K. Brooks, University of Florida, Gainesville (see Fig. IIE-1, In: Jones, et al., (eds.) 1973. A summary of knowledge of the eastern Gulf of Mexico, 1973. SUSIO, St. Petersburg, Florida). Cover layout and Appendix VI were prepared by Stuart M. Smith, St. Petersburg, Florida.

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GLOSSARY

CONCLUSIONS AND RECOMMENDATIONS
OF THE
CONFERENCE AND WORKSHOPS ON
MARINE ENVIRONMENTAL IMPLICATIONS OF
OFFSHORE DRILLING IN THE EASTERN GULF OF MEXICO

St. Petersburg, Florida

January 31 - February 2, 1974

Conclusions and Recommendations

Prepared by

Harris B. Stewart, Jr.
NOAA/Atlantic Oceanographic Meteorological Laboratory
Miami, Florida

OBJECTIVES

The objectives of the studies to be initiated by the Bureau of Land Management (BLM) in the MAFLA area of the eastern Gulf of Mexico as explained to the conference/workshop participants, were twofold:

1) an initial or short-term baseline study in the vicinity of the present lease tracts and,

2) a continuing or long-term study in the entire eastern Gulf of Mexico, including the areas specified above.

* * *

1) Initial (or Short-Term) Study

The time frame of this study was given as follows: A Request for Proposals (RFP) prepared by February 15, an approximate 30-day response period, a 14-day review period by BLM, and the letting of contracts by BLM immediately thereafter--about April 1. The basic objectives of the short-term contracts are to obtain baseline samples and data from the present lease tracts before any exploration commences. In this respect it is envisioned that commercial drilling rigs might be ready for placement in the high priority areas of the Destin Dome and Mobile South tracts as early as 60 - 90 days from the date of the conference. Thus, the sampling program must be operational in the 30 - 45 day period immediately following April 1. The processing of the samples and data was not expected immediately, although the results would immediately be of value for future planning of the continuing and/or long-term studies.

For this initial study, the problems stated in the simplest terms were: WHICH PARAMETERS, WHERE, WHEN, AND HOW. In other words, the short-term program should be directed to the geographic, spatial, and temporal factors, and the standardized methodology for sampling those specified parameters which might be expected to be modified by offshore drilling. The budget in the initial phase was stated to be $1.3 million in Fiscal 1974.

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2) Continuing (or Long-Term) Study

Subsequent to the very rapid initial baseline study, there is to be an extended 3 or 4 years of studies to provide comprehensive (or post-baseline) environmental data for the entire area of the eastern Gulf of Mexico, including the areas covered in the initial study. Funding levels are to be about \$3.1 - \$3.5 million/year for this period and at maintenance (monitoring) levels of about \$1 million/year thereafter.

MEETING PROCEDURES

Following formal papers by Federal and State agency representatives, an ocean lawyer, an industry representative, and four scientific sessions on the present state of knowledge of the physical, biological, chemical, and geological oceanography of the eastern Gulf of Mexico, four workshops were conducted to develop and prepare recommendations for the Bureau of Land Management and the Interagency Management Committee relative to required pre-drilling baseline studies in the MAFLA lease areas and longer-term comprehensive studies in the eastern Gulf of Mexico. These workshops covered Physical Oceanography, Biological Oceanography, Geological Oceanography and Chemical Oceanography. On the final morning, each workshop Moderator presented the results of his respective workshop to the full meeting and these were followed by questions and discussions. That afternoon the workshop Moderators, the conference/workshop steering group, representatives of the Bureau of Land Management, and such members of the Interagency Management Committee as were present (BLM, EPA, NOAA, USGS, Florida and Mississippi) met to review the results of the conference/workshops and to decide how these could best be provided to the Interagency Management Committee in a form most useful for their meeting to be held in Washington February 5, at which time they were to initiate work on the RFP for the MAFLA lease area research. Because final written documentation was not available from three of the workshops until late that afternoon, the Chairman of the final morning's summary session agreed to consolidate the conclusions and recommendations, generated by the workshops and subsequent discussions, into what must be considered only a tentative preliminary draft. The draft was made available to the Interagency Management Committee for their use on February 5. In the meantime the draft was distributed to each of the workshop Moderators for his comments and any changes or additions prior to final preparation as the formal conclusions and recommendations of this conference/workshop.

GENERAL RECOMMENDATIONS

1. It was the consensus of those meeting the final afternoon of the conference/workshops that the conclusions/recommendations of the sessions as they relate to the initial (short-term) baseline studies should be utilized as a framework within which to prepare the RFP, and against which to measure the adequacy of the proposals expected to be generated in response to it. There was unanimous agreement that the RFP should not

specify such details as sample spacing, actual station locations, instrumentation and analytical techniques, repeat sampling schedules, etc., but that these should be left up to the proposers. However, many of these details are spelled out in the more specific recommendations that follow, and these can be used as a measure of the degree to which any proposal is scientifically adequate to carry out the needed work.

2. The importance and absolute necessity of good data management was stressed throughout the meetings, and the following statement was presented by the representative of the National Environmental Data Service for consideration for incorporation in the RFP and/or in the final contract; it should apply both to the contractor and to any subcontractors:

   > "A first level inventory of data collection activities must be reported to EDS within 30 days after completion of each cruise or data collection phase. A National Marine Data Inventory (NAMDI) form, or equivalent, accompanied by an annotated sketch of the trackline or survey area, should be completed and submitted to the NODC. The data themselves, with a completed Data Documentation Form, shall be submitted to EDS within one year of collection.
   >
   > "A second-level inventory will be required for data which cannot be shipped within the one-year period, and for special classes of observations such as bottom photographs and biological and geological samples. The details of this second level inventory will be worked out between the appropriate data center and the data originator.
   >
   > "At the request of the originator, EDS will permanently retain original records of the following types: navigational abstracts and trackline sheets; geophysical, XBT and STD strip charts; fathograms; and supplemental records which will permit subsequent users to evaluate and process original records."

3. In preparation for the longer-term studies, in particular, every attempt should be made to provide funding for the analysis and interpretation of data and samples already collected from the eastern Gulf of Mexico but not yet worked up. In turn, funding should be provided to publish same as appropriate.

4. Whenever geological, chemical, and biological samples are obtained for baseline studies and analysis, a sample of sufficient size should be collected that a representative sample can be preserved and stored for additional analyses if desired

at a later date. The repositories for such samples should be identified prior to the initiation of the short-term baseline studies; this information should be brought to the attention of all appropriate persons for action.

SPECIFIC RECOMMENDATIONS

(Note: These recommendations were in large measure taken verbatim from the written reports prepared by the workshop Moderators and their Rapporteurs. The recommendations also include material brought up during the summary session the final morning and the subsequent discussions the final afternoon.)

A. Physical Oceanography

1. An operational forecasting procedure for predicting the trajectory of surface-transported oil spills from the MAFLA tracts should be developed using state-of-the-art methods, incorporating applicable and available data, and particularly including a parameterization of extreme meteorological conditions.

2. A probability distribution model for surface-transported materials (i.e., the probability of location as a function of time) should be developed for each lease area encompassing the considerations in Recommendation 1 above.

3. Methods, instruments, and operational procedures for verification and improvement of the above models should be developed. Methods and instruments should be subject to a continuous program of comparison and, where practical, to intercalibration.

4. A probability distribution model, similar to that in Recommendation 1 above, should be developed for the transport of the entire water column, so that the distribution of pollutants originating from the MAFLA petroleum exploration and production sites might be predicted. Where appropriate, this model should be functional on a seasonal and vertical basis. This would necessitate further studies of the mass field. Available data, whether from direct measurements or indirect inferences of the water motion, should be included in the model. The response of the circulation to severe meteorological forcing should be included. Since this model would be extremely useful in planning for the sampling station locations during the baseline study and for the longer term study, a capable scientist or organization should be funded immediately to compile the presently available data and develop this model.

5. Methods, instruments, and operational procedures for verifying, augmenting, and extending this model should be developed. These procedures should utilize appropriate state-of-the-art

methods and instrumental systems and should be subjected to a regular program of calibration and intercomparison.

6. Since the horizontal coherence of the wind, barometric pressure, and temperature fields is not well known in the eastern Gulf of Mexico, a number of remedial actions should be taken:

   a. All available weather stations along the Gulf Coast should be brought into full operational and reporting capability.

   b. A number (probably about 5) of off-shore meteorological stations should be established for wind, pressure, and temperature measurements. These stations may be buoys or towers; their locations should be determined by a select group of qualified advisors.

   c. The above off-shore stations should be equipped for wave and tidal height observation and recording.

   d. All drilling rigs, temporary or permanent, should be required to install meteorological and tidal-height recorders and to provide a mechanism for making their data immediately available to appropriate agencies or individuals (see Recommendation 37).

   e. The off-shore instrumentation in b, c, and d above should be "hurricane-proof."

7. Arrangements should be made to obtain high-quality wave data (directional and power spectra) at a number of sites (about 20) in locations that would be subject to a variety of meteorological conditions. These measurements should be at near-shore locations selected by experts in coastal deposition and erosion processes. Corresponding offshore locations should be instrumented to obtain wave data for tracking purposes.

8. The National Environmental Data Service (EDS) should be requested to prepare and make available to interested persons a convenient source book of "extreme" environmental conditions observed in the eastern Gulf of Mexico. This report should minimally include winds, temperature, and sea state, and the data should be presented by season and by mini-region.

B. Biological Oceanography

(Note: The group assembled for the biological workshop numbered in excess of 120 persons. Clearly it would have been advantageous for a unified consideration of the biological problems relevant to the BLM objectives. However, the time constraints and impracticality of such a workshop size necessitated a division into concurrent meetings of subgroups along disciplinary lines. These were defined as PLANKTON, BENTHOS, NEKTON, and an "Interdisciplinary" group. These subgroups drafted recommendations which were then combined and jointly submitted).

9. Plankton distribution in the eastern Gulf should be investigated in both the short-term and long-term programs. However, sufficient numbers of plankton samples are presently available for initial baseline data and additional samples for distributional studies are unnecessary.

10. Further sampling of the plankton at selected stations in lease and control areas should be done, however, in both the short-term and long-term programs to determine standing crops and primary productivity, and other aspects of phytoplankton metabolism. For zooplankton, data are needed on diet, growth, reproduction, respiration, excretion, biomass, and levels of trace metals and hydrocarbons. Similar dynamic studies are required for microorganisms.

11. Sampling stations are needed in the inshore area (e.g., St. Andrew Bay), in the actual lease tracts (e.g., the Destin Dome area), and at the offshore reference site previously established at 27°N, 86°W from which time-series data are already available.

12. Sampling of fish for adequate baseline data is of little value in the short-term study but is of considerable value for the long-term study. Thus no fish sampling should be included in the former but should be included in the latter.

13. Four major sampling areas should be included in the long-term study: nearshore benthic, middle shelf benthic, outer shelf benthic, and neritic.

    a. The nearshore benthic should include river mouths, marshes, beaches, jetties, and mangrove swamps.

    b. The middle-shelf and outer-shelf benthic should include reefs, sand bottoms, shell-rubble bottoms, and all other types of substrates.

    c. The neritic zone should be sampled for eggs and larvae and for organisms associated with floating objects, such as Sargassum and its epiphytes.

14. Catch and effort data from recreational and commercial fisheries should be utilized in all studies.

15. Sampling methods necessarily must include assorted gear, for not all species can be sampled by a single method; thus, nets, rotenone, traps, trawls, seines, acoustic devices, and other types of gear should be used as appropriate. Additionally, plankton nets and trawls are required for capturing eggs, larvae, and juveniles.

(Note: Recommendations 12 through 15 refer only to the fish component of the nekton. Lack of reference to other nektonic organisms--e.g., squid and crustaceans--merely reflects the time constraints imposed on the workshop and does not imply any lack of importance of these components of the nekton.)

16. Underwater reconnaissances should be conducted using submersible vehicles in designated areas to classify and map benthic communities and bottom types. Studies of the benthos utilizing such vehicles should be planned as multidisciplinary operations to meet the requirements of the biologists, geologists, archeologists, and--to a lesser extent--physical and chemical oceanographers. In particular such vehicles are extremely useful for sampling organisms and sediments as a function of their observed geographic variability.

17. Quantitative sampling procedures should be designed for the benthos, demersal fishes, epifauna, and infauna (both meiofauna and larger organisms). The precision should be such that comparative and repetitive results can be obtained.

18. Benthic sampling should be carried out in coordination with sampling for sediments, suspended matter, hydrocarbons, and trace metals in the water column as well as in conjunction with sampling for other purposes.

19. Benthic algae at the offshore towers, Stage I and Stage II off Panama City, Florida, and other control areas should be examined for:

    a. growth rates in situ in relation to temperature and other environmental factors;

    b. presence in relation to depth and season.

20. Seagrass distribution and relative densities in the Eastern Gulf of Mexico should be examined and growth rates studied relative to season and depth, density and biomass, and epiphytes and grazers.

21. For non-fish vertebrates, such as marine turtles, migratory birds, sea birds, dolphins, manatees, and whales, it is recommended that studies be conducted (and expanded upon where data exists) on the distribution, abundance, and physiological responses of these animals to foreign substances introduced as a result of offshore drilling, especially in view of their aesthetic and intrinsic value.

22. An inventory of, and where possible, a synthesis from the following samples and data should be made:

a. biological samples by type, location, method, date, and time of collection;

b. existing data, published and unpublished, by location and type;

c. photographic records of the MAFLA area from satellite, aircraft, and surface and subsurface vehicles.

23. Suitable repositories should be established to store specimens of representative and/or key species of the total biota of the area (plankton, nekton, benthos, and non-fish vertebrates) for studies of the presence of trace elements, heavy metals (man-synthesized compounds in general), hydrocarbons, adenosine-tri-phosphate (ATP), and for histopathological studies. Similar materials should be preserved for future studies, the nature of which are unforeseen at this time.

24. Sampling should be standardized to the extent practicable in regard to location, time, methods, and gear used. Once these procedures have been established for particular parameters, they should be maintained for the sake of consistency and comparability of results.

25. Funding support (from BLM or other sources) should be obtained for the following:

    a. expediting the examination and analyses of existing collections from the area;

    b. obtaining shiptime and the coordination of the use of research and other vessels;

    c. sorting and identification of samples;

    d. automatic data processing (ADP) and archiving of data;

    e. speedy publication of results;

    f. deposition and curating of specimens in appropriate museums.

26. In considering the impending operations in the MAFLA area related to exploration, exploitation, production, and transportation of oil, chronic and catastrophic spills are believed to have greater adverse biological consequences than spills of drilling muds and brines and the erection or sinking of drilling structures and pipelines. In the event of oil spills, it is judged that the most vulnerable components of the ecosystem are the benthos. The benthic shellfish are the most vulnerable of the exploitable living resources, and the sea birds, turtles and marine mammals, of the intrinsic living resources. Therefore special attention should be paid to these organisms viz a viz possible detrimental effects from oil spills.

27. It was further felt that the effect of potential spills on public amenities with strong biological aspects should not be ignored. Such amenities include the biota of the estuaries, inter-tidal and sub-littoral zones, underwater parks and preserves, and associated habitats.

C. Chemical Oceanography

28. The chemical program should be designed in such a manner as to provide the information needed to establish an adequate baseline of concentrations and transport processes against which to compare possible future impacts on the environment related to oil drilling and related operations. The experimental design must provide the data base by chemical analyses for hydrocarbons and other biologically significant substances in the major reservoirs of concern--water column, biota, sediments, suspended particulate matter, sea surface, and lower atmosphere--so as to develop predictive models for the dispersion of these substances in and through the shelf system (see Recommendation 4).

29. A complete system of interlaboratory calibration of chemical sampling equipment and techniques and analytical procedures must be an integral part of both the short-term baseline studies and the longer-term studies. Many of the biologically important substances associated with oil production occur at trace levels in the eastern Gulf of Mexico shelf system and are therefore difficult to measure accurately. If firm conclusions regarding possible chemical changes in the system are to be drawn from the chemical measurements, there must be an extremely high confidence level associated with the sampling and analytical methods.

30. Hydrocarbon levels should be determined in key organisms in the benthos, plankton, and nekton, in the sediments, and in the water (including suspended particulate matter and tar balls). Attention should be focused not only on the effects of spills but also on the effects of long-term low-level exposures on the organisms.

31. Surveys of the distribution of low-molecular-weight hydrocarbons in water can be effectively carried out in conjunction with underway biological or geophysical surveys by employing the gas "sniffer" system. This will complement the analyses of the high-molecular-weight compounds analyzed from extractions from the sediments and organisms. The latter system can also be employed on stored samples. With the "sniffer" system, large areas can be covered in a quasi-synoptic fashion, and the results can be used to extend or correlate with the more intensive and time-consuming studies of cores and organisms from discrete points. Both man-imposed and natural hydrocarbon baseline levels should be determined.

32. Visible sheens on the sea surface are a sensitive indicator of activities associated with drilling rigs, pipelines, terminals, and refineries as well as with natural phenomena such as oil and gas seeps. Rapid detection systems, including satellite sensing, are available to detect sheens. Possible influences and interactions of sheens with biological and chemical systems should be studied.

33. Certain substances such as barite, drilling muds, brines, resuspended materials, and heavy metals added to the marine environment as a consequence of drilling and production operations may or may not in themselves be harmful. They may, however, be useful indicators of the sphere of influence of drilling rigs, pipeline trenching, and other associated activities. Because their transport through the shelf system of the eastern Gulf of Mexico is intimately related to water movement, these measurements should be integrated with the program in physical oceanography (see Recommendation 4). Tar balls, because of their capacity to accumulate trace substances such as chlorinated hydrocarbons, are recommended as pertinent subjects of inquiry in the MAFLA area.

34. Fluxes of hydrocarbons across the sediment-water interface and the sea-air interface should be investigated and monitored as well as the dissipation and degradation of hydrocarbons and other pollutants in the sediments.

35. Changes in nutrient levels may reflect perturbations imposed on the ecosystem by both natural and man-made sources and should be monitored and studied.

36. Two discrete but coordinated approaches to the problem of sampling locations encompass both an early program in the high-priority areas mentioned in Recommendation 43 and a longer term study of the entire shelf area in the eastern Gulf of Mexico. Ultimately a continuing monitoring program should be mounted with the design of such a program based to a large extent on the understanding acquired during the short-term and longer-term projects.

37. A chemical sampling grid with a 10 km spacing between sample points is recommended extending from the high-tide mark on shore to the outer edge of the shelf. Justification of such a sample spacing is based on empirical experience in other shelf programs as a compromise between thorough coverage of sedimentological and biological parameters and logistic feasibility. In addition, unpublished data suggest that the detection of any effects from discrete oil spills on sediments on the open shelf is limited to about 8 km from the source of the spill. However, these grid spacings must

be flexible in order to accommodate local conditions and objectives. Special attention should be paid to pipeline corridors and terminal facilities prior to final selection of sites. Moreover, not all samples need to be analysed immediately, and a system of archiving of samples appropriate to the above objectives should be established (see General Recommendation 4).

38. A limited number of atmospheric sampling stations should be established 10 km offshore. These should be at the same sampling locations for the measurements called for in Recommendation 6.

39. To the maximum degree possible, the chemical sampling program should be coordinated with the other sampling programs. That is, the same bottom samples wherever possible, and certainly the same bottom sample station, should be used by all disciplines. Where water column and atmospheric measurements are called for, these should also be made at the same stations and at the same times.

40. A minimum of quarterly sampling for water chemistry is recommended, and at each of these stations serial samples should be collected over a minimum of two tidal cycles.

41. A special effort should be made to obtain samples during high-energy conditions such as tropical storms, frontal passage, and hurricanes.

D. Geological Oceanography

42. Although no adverse environmental effects are anticipated during the site survey stage, the site preparation stage for rig emplacement often includes the extensive use of shell fill. All anticipated baseline sediment sampling within the MAFLA lease areas should be completed prior to initiation of filling operations.

43. Bottom sediment samples should be obtained on a flexible grid of generally 1- to 2-mile spacing within the actual MAFLA lease areas. In addition there should be a high-density sampling along selected transects at half-mile intervals with one-eighth mile spacing over selected portions. Areas for special sampling can be identified during the submersible surveys called for in Recommendation 16. Two down-slope transects and two along-slope transects per lease area are considered as minimal.

44. It is realized that it will be extremely difficult to reoccupy exactly a station previously sampled and that spacial variations in sediment characteristics between two samples taken within feet of each other may totally mask any changes in the same location with time; nevertheless, it is recommended

that bottom sediment sampling stations be sufficiently well located that repetitive samples with time can be obtained for geological, biological, and chemical sampling. One possible technique is to install recall-markers on the bottom and to use divers as the major sampling mechanism.

45. Of special importance is the inventorying of existing sediment and rock samples and information from the MAFLA area (see General Recommendation 3).

46. Surface materials on the bottom should be sampled by appropriate means for the type of bottom encountered. Box cores and grab samples will be adequate in most instances, and provisions must be made to obtain samples of sufficient size to allow samples to be made available to the biologists for studies of the in-fauna and epifauna, to the chemists for their studies, and for archiving designated sample repositories (see General Recommendation 4).

47. Because of the large expanses of sandy bottom in the MAFLA area, vibracore samples will probably be needed. These should be planned at one-mile intervals in the detailed transects. This would be a one-time operation and not required for the monitoring program.

48. Bottom sediment samples should be obtained in order to evaluate the following:

    a. the factors relating to possible smothering of the benthic epifauna by discharged drilling mud or drill hole cuttings;

    b. the variation of barium in the sediments for comparison following the discharge of barite drilling muds into the environment;

    c. the possible effects of brines discharged in association with drilling and production;

    d. the possible enhancement of the hydrocarbon concentrations as a result of drilling and production (see Recommendation 28);

    e. the possible enrichment of the sediments in heavy metals related to the discharge of brines (see Recommendation 33);

    d. the possible variation in concentration of lead isotopes.

49. Analyses of all sediment samples should include the sediment parameters of size frequency distribution, mineralogy, distribution patterns, accumulation rates where possible, and an evaluation of the sediment sources.

50. For suspended sediments, in the pre-drilling phase, five-gallon samples at the surface, mid-depth, and near the bottom should be collected on a 10 km grid,first in the Destin Dome area and then in areas of lower priority. Monthly sampling for one year is recommended to establish baselines and annual trends.

51. Transmissometer measurements should be made concurrently with the collection of the suspended sediment samples. If possible, dissolved oxygen measurements as well as measurements of the water temperature, salinity, and currents should be made at the same time and place (see Recommendation 18).

52. Once actual drilling has been started, vertical transmissometer measurements should be made on at least four equally spaced radial transects originating at an active rig site. These data can also be used as verification of the model developed in response to Recommendation 4. Water samples for suspended sediments should also be obtained at depths dictated by the transmissometer measurements so as to identify the trajectory of suspended materials discharged at the rig.

53. Sediment traps placed in an array determined by the model proposed in Recommendation 4 might be used to determine the accumulation rates and the bottom distribution of materials injected into the environment at the drilling site which might have a smothering effect on the epifauna. However, new techniques for studying sediment movement under wave activity need to be investigated.

54. Laboratory analyses on collected suspended sediment samples should include clay mineralogy, scanning electron microscopy to identify particle types to discriminate between natural and man-induced particles, size analysis, organic/inorganic carbon ratio determinations, and analyses of heavy metals and toxic materials.

55. Suspended sediment studies are included to quantify suspended sediment discharges from drill sites, to identify potentially toxic additions to the environment, to aid in identifying transport paths of materials from the drill sites, to identify particle types that might adversely affect critical stages in the growth and development of marine organisms, and to provide an answer to the question as to whether or not there is a degradation in water quality from an increase in water turbidity that might be biologically or aesthetically unacceptable.

56. Sediments in the area immediately surrounding a drilling site should be monitored at least once every three months during drilling and not less than yearly during the production phase. Analyses should be directed toward determining any possible effects resulting from the discharge of brines and drilling muds as well as from chronic or catastrophic oil spills.

57. Although the various petroleum companies have undoubtedly conducted detailed bathymetric and geophysical surveys in each of the lease areas on which they bid and particularly in those in which they will operate, these data are generally considered as proprietary within the company and are not available. Therefore as part of the longer-term studies the National Ocean Survey should be requested and funded to produce detailed bathymetric maps of each lease area at scales and contour intervals commensurate with the needs of the scientific studies that will use these maps as base maps. Desired scales and contour intervals will vary as a function of the bottom topography encountered in each area,and all the way to the beach,but in general scales of 1:80,000 to 1:20,000 and a contour interval of five meters should be adequate. For the longer-range studies, existing bathymetric data in the NOS files, supplemented by additional surveys where needed, should be used to compile a new and accurate bathymetric map of the eastern Gulf of Mexico at a scale of 1:250,000 and a contour interval of five meters.

58. Geophysical surveys for magnetics, gravity, and sub-bottom structure should initially be limited to the areas under lease and proposed pipeline corridors and later continued on a long term basis with a less dense grid, throughout the MAFLA area. Emphasis should be given to continuous underway geophysical measurements that can be conducted simultaneously and preferably in conjunction with other oceanographic measurements. In particular these studies should be directed toward the identification of geological structures and potential hazards, natural submarine discharges of water and hydrocarbons, the transport of bottom sediment, and marine archeology. Seismic side-scan sonar and "sniffer" surveys (see Recommendation 31) should be begun as soon as possible, in the areas identified for early drilling, and later continued on a long-term basis throughout the MAFLA area.

59. All surveys and sampling locations must utilize the highest precision navigational control possible so that the resulting data are of maximum usefulness to follow-up studies (e.g., repeat surveys), before-and-after comparisons, and to the sampling in the physical, biological, chemical, and geological programs.

60. Every effort should be made to obtain copies of surveys made by or for the petroleum companies in the eastern Gulf of Mexico in order to prevent costly duplication. Possibly this requirement could be included by the Geological Survey as a condition to the issuance of any drilling permit.

61. To prepare for an adequate evaluation of the effects of a possible oil spill, studies should be conducted on the effects of oil on beaches, marshes, and swamps along coasts ranging

from high-energy environments to low-energy ones. In particular the effects of introduced oil on the overall sedimentary regime should be evaluated.

62. The topmost layer of bottom sediments (ca. 15 cm) should be sampled to evaluate the possible historical record of plankton and trace metals in the sediments.

63. For the short-term studies, the geographic extent of the Karst topography on the MAFLA shelf should be determined.

64. As part of the longer-term studies, a coordinated project should be developed jointly with the physical oceanographers to provide an understanding of the dynamics of the sedimentary regime on the eastern Gulf of Mexico shelf. Particular attention should be paid to the effect on the sediments of environmental extremes; e.g., hurricane-generated waves, incursion of the Loop Current, and storm surges (see Recommendations 7, 8).

65. The possibility that submarine sediment lithification is dominantly a surface phenomenon (cf. the Bahama platform and the Persian Gulf) with unconsolidated sediments at depth should be investigated.

INTRODUCTORY
REMARKS

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Objectives of Conference and Workshops

Robert E. Smith
State University System of Florida
Institute of Oceanography
St. Petersburg, Florida

The ENVIRONMENTAL STATEMENT, both the draft and the final copy, for a proposed 1973 Outer Continental Shelf OIL and GAS GENERAL LEASE SALE OFFSHORE MISSISSIPPI, ALABAMA, AND FLORIDA, has received broad dissemination and in turn has been critiqued by a substantial cross section of individuals and groups representative of Federal and state government, academia and industry. It is not the purpose of this conference and associated workshops to present any type of synopsis or critique of the Environmental Statement per se; but it is a purpose of the three days of sessions to address environmental issues that have been, and are being, associated with statements that were and were not presented in the document.

I will not belabor this but, suffice it to say, the Outer Continental Shelf oil exploration and production activities in the eastern Gulf of Mexico have catalyzed the interests and concerns of a significant number of individuals and organizations as exhibited by the persons assembled for these sessions. However, it should be pointed out that the marine environmental implications of offshore drilling are one of many activities which must be given serious consideration if these are to be handled in any manner other than by the typical inefficient and overly expensive crash program or brushfire approach.

The interests and concerns today happen to be petroleum exploitation in the eastern Gulf; yet tomorrow figuratively speaking, many of the individuals present, and organizations represented, will be confronted with making decisions on the marine environmental implications of such activities as establishing nuclear fueled power plants offshore; evaluating the feasibility of constructing sewage outfalls on the Continental Shelf or addressing the subject of site selections for offshore disposal of household and industrial wastes; mining and farming the coastal and offshore areas will need to be considered and so on. During these deliberations many of us will be prone to dwell on the potential deleterious effects that might be associated with the offshore activities. But, I implore all of us to take into consideration the potential beneficial effects that can result as part of man's activities in the further development of the living and non-living resources of this area. There can

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be numerous beneficial effects if we as individuals, and collectively, are willing to plan accordingly. And, I stress offshore areas in general, not specifically the eastern Gulf of Mexico. Yes, these conference/workshop sessions that are convening this morning have been brought about by the impending OCS petroleum operations in the eastern Gulf, but these activities represent only a part of our challenges of the future throughout the entire world's marine environment.

There has been considerable consternation associated with the planning and development of these conference/workshop sessions as many of you are aware. Therefore, I think that it would be proper at this time to provide an abridged synopsis of how they have come about.

Why? I feel this question has been adequately covered in my preceding statements and in a memorandum that will be cited later.

When? The time frame is the hooker. In late November 1973, Dr. Frank T. Manheim, then of the U. S. Geological Survey, Woods Hole, and now Chairman of the Department of Marine Science, University of South Florida, contacted Dr. James I. Jones, Research Coordinator, Florida Coastal Coordinating Council, to discuss the marine environmental implications of offshore drilling in the eastern Gulf. The discussions prompted calling a meeting here in St. Petersburg on December 10, 1973. It was decided in the meeting that a "trial balloon" should be launched to determine whether sessions such as now programmed would be of sufficient interest to a significant number of people, and in particular the right people, to warrant the planning and conducting of such sessions; and at the same time, to establish appropriate dates if the meetings were to take place. A memorandum was prepared and mailed on December 13, 1973 to more than 200 persons for the initial poll (Appendix I).

In the meantime, it was recommended that I present the subject of the December 10 meeting held in St. Petersburg, and the December 13 memorandum that resulted, at the Florida Interinstitutional Committee on Oceanography (FICO) meeting scheduled for December 18 to be held at Rosenstiel School of Marine and Atmospheric Science, Miami. In other words, the FICO members, representing Florida State University (FSU), Florida A & M University (FAMU), University of Florida (UF), University of South Florida (USF), University of West Florida (UWF), Florida Atlantic University (FAU), Florida Technological University (FTU), Florida International University (FIU), University of North Florida (UNF), Rosenstiel School of Marine and Atmospheric Science (RSMAS), NOVA University (NU), Florida Institute of Technology (FIT), U. S. Naval Coastal Systems Laboratory (NCSL) at Panama City, would constitute the next poll (membership list of FICO Appendix II). If the group felt that what was being proposed was in principle warranted, based on all things considered, then it would be further pursued.

FICO did agree in principle, and in turn established an ad hoc steering committee consisting of Drs. William Richardson, NOVA; Warren Wooster, RSMAS; Frank Manheim, USF; James Jones, FCCC; Thomas Hopkins, UWF: and me, SUSIO. I was appointed chairman and we were charged to proceed with all haste practical. The identification and follow-up of potential funding sources and the determination of appropriate dates for the meetings were the first milestones that had to be met. As it turns out the selection of dates was in most part firmed up on the basis of the ultimate sources of finding support.

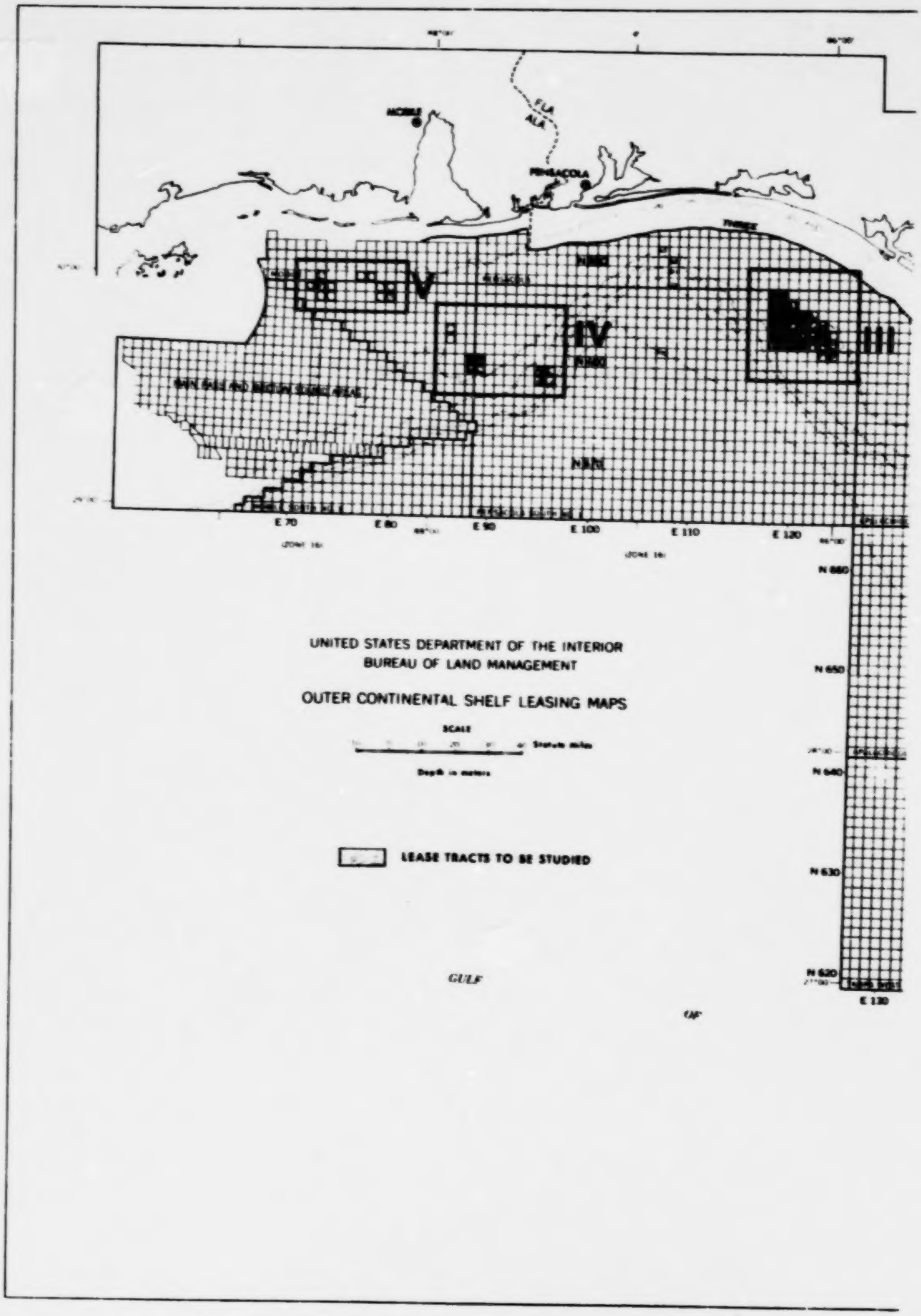
The FICO members and many others felt very strongly that it was impractical and virtually impossible to attempt to organize and convene such an important set of sessions in the ridiculously short time frame we were limited to between middle December 1973 and late January 1974, roughly 45 days. We thought at the time, dates in February, March or April would have been better. However, the steering committee was strongly advised by government agency representatives that to have the greatest meaning regarding the subject of marine environmental implications of offshore drilling in the eastern Gulf of Mexico, it would be mandatory to select the earliest possible dates. This weighed the balance to the impractical side. But interestingly enough, by this time we had commenced to receive a flood of positive responses to the December 13 memorandum that had been disseminated as the "trial balloon." Representatives of government, academia and industry were in agreement that there was definitely a pressing and justified need to have the proposed sessions but they would prefer to have the January 31, February 1, 2 dates, as suggested in the initial memo, slipped back in order to allow for some much needed planning time. Nevertheless, the consensus of opinion, derived from numerous communications, both letters and telephone calls, was that if the determination was made to "pull-all-stops" in order to meet the January 31 start date, then to count them in, and to alert them of same in order that they could plan to participate. An announcement/invitation firming up the subject, time and place for the conference/workshops was disseminated January 15 (Appendix III).

Obviously, based on the many things considered, and certainly not by unanimous decisions, we find ourselves here today to participate in the program as presented (Appendix IV). Admittedly, probably each of us would have preferred to have more lead time; on the other hand, I believe that the many people responsible for planning and developing the conference and workshops have done a tremendous job. I want to express my appreciation to each of you who have been involved in this. I want to also express appreciation on behalf of everyone here to everyone here, as each of us should play important roles in the program overall. We have gathered, but we must now participate in our own way to make these sessions productive and meaningful.

If I were all-knowing I would like to present an overview of who has, or is to do what, when and where with regard to the past, current and future Outer Continental Shelf development activities; in turn, I would like to cite the responsibilities, roles, goals, interests, concerns and involvements of the respective federal and state agencies, of industry and of academia. However, since I am not all-knowing, nor do any of my colleagues consider themselves to be, a representative cross section of qualified individuals agreed to assemble for this purpose. As a result of their presentations, the papers to be given in the scientific sessions and the in-depth discussions that are to be carried on in the workshop sessions, I trust we will be able in the three days to: jointly define by priority the critical research and/or information needs in the subject disciplines and geographic area; to develop a scientifically sound and relevant interdisciplinary program; and to identify the qualified, appropriate and available persons to conduct same. Furthermore, in so doing we must be mindful of the fact that adequate data and information management must be an integral part of the proposed plan. Too often this is overlooked both in the initial planning and the ultimate goals; let's not allow this to occur with the current concerns.

Introduction of Speakers

OUTER CONTINENTAL SHELF MAP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UNITED STATES DEPARTMENT OF THE INTERIOR
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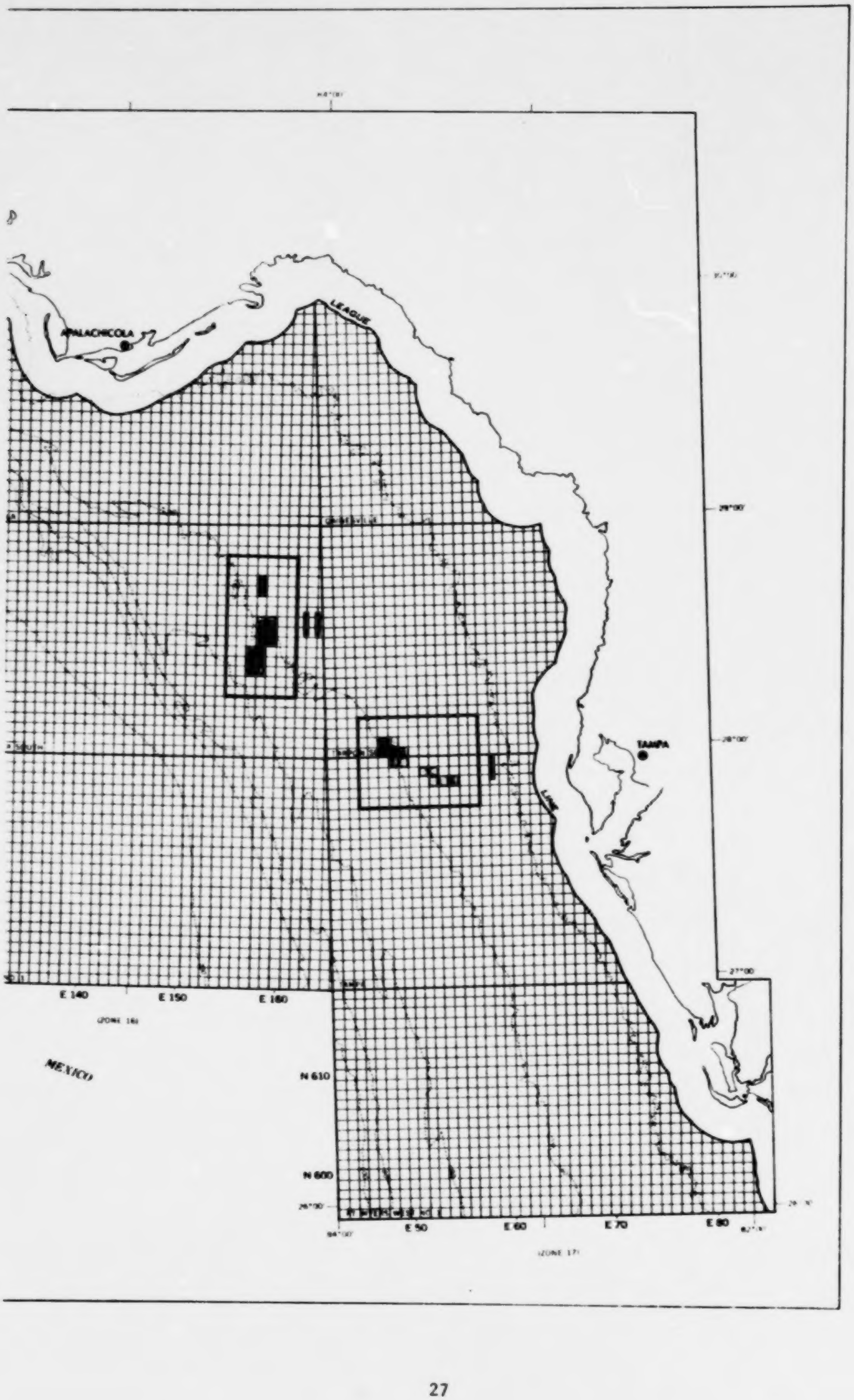
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AGENCY AND INDUSTRY PRESENTATIONS

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Bureau of Land Management Responsibilities and Goals as Pertains to the Eastern Gulf of Mexico

John Sprague
Bureau of Land Management
Division of Marine Minerals
Washington, D. C.

The purpose of the talk was to describe the responsibilities of BLM and our role in the conference proceedings. A discussion of BLM leasing and related responsibilities on the Outer Continental Shelf was presented. A discussion of oil and gas leasing activity was given as well as a discussion of BLM's marine organization and structure. The objectives of BLM in its environmental research in the Northeast Gulf of Mexico in general and on lease sites in particular were presented. A discussion was also presented of administrative and personnel actions associated with the research. The talk concluded by identifying ways in which the conference/workshops might help BLM in its environmental research mission.

Editor's Note: If additional specific information pertaining to the subject of the presentation is desired by the reader, please contact

Mr. John Sprague
U. S. Department of the Interior
Bureau of Land Management
Division of Marine Minerals (732)
Washington, D. C.

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Environmental Protection Agency's Role, Interests and Responsibilities With Respect to the Outer Continental Shelf Development

Andrew McErlean
U. S. Environmental Protection Agency
Washington. D. C.

EPA with respect to MAFLA, has at the working level, been trying to initiate and develop the scientific basis for management decisions. At the outset it is necessary to underscore our belief that energy development and environmental concerns are not necessarily incompatible. To this end EPA has devoted a large amount of time and effort to the MAFLA issue and the implications of this. This activity is highly significant in and of itself: however, one of the most important implications of MAFLA is as it relates to the Outer Continental Shelf development in general.

As you know, similar development is planned in other coastal waters, off Alaska, California, Texas and the Atlantic Coast. Development of these areas necessitates a data basis that will allow wise and informed management decisions. The enormity of these projects, the potential problems they present, and the need for a sound technical basis argues for a large degree of cooperation and coordination among federal, state and private institutions and agencies. With respect to these areas and to MAFLA, both time and funding are finite. These limitations impose restraints on the scope and subject matter of the investigations, and require that suggested projects be compared to the management needs and pass the tests of pertinence, achievability and value. These limitations also require that objectives be clearly stated and that the results be factored into the management scheme.

It is my hope that the concerned agencies will insist that each project or effort be vigorously justified and its potential usefulness be evaluated before a project is initiated. This is really a way of saying that we have neither the time nor the money to study the universe. It is also a way of saying that "applied" research is required. The distinction between "basic" and "applied" research has eluded me except for the observation that research findings lose their "basic" label when they are applied to a practical problem. We are all here at a meeting supported by various federal agencies because we need your advice as to how and what should be studied in the Eastern Gulf to establish a meaningful technical program that can be used by management.

The specific legislative concerns and responsibilities of EPA have to do with the platforms and the materials they might discharge. These discharges will be permitted under the NPDES program, and the enabling legislation or legal citations for this authority are contained in

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P. L. 92-500, section 502(12). This is the narrowest possible interpretation of either our interests or responsibilities with respect to OCS. There are many other ways in which EPA is directly or indirectly involved in the entire gamut of OCS operations in the wider sense. It is not possible to define all of these interests or responsibilities; however, some limited citation of these might be of interest--such as section 104(N) of Public Law 92-500 which mandates the administrator to concern himself with estaurine areas, the ocean dumping concerns, EPA's advisory role with respect to spills, and the presence of the National Marine Water Quality Lab whose mission it is to provide the scientific basis for the establishment of marine and estuarine water quality standards.

The problems posed by rapid OCS development are myriad. Indeed, we may not even know enough to recognize all the real or potential problems, yet development is a certainty. Nature is constantly surprising us by tweaking the nose of accepted axioms and maiming sacred cows. One of my real fears as a scientist and a taxpayer is that of asking working scientists to indiscriminately reply to the question, "What needs to be done to understand a particular activity or its implications?" This is not unlike giving an automotive mechanic Carte Blanche with a '61 Chevy.

One card-carrying cynic, in criticizing the current vogue in "environmental studies"(which incidentally bears the wicked title of "The impact of impact statements"), cites a list of seven commandments which I will repeat here for your amusement and consideration:

1. Thou shalt frame the ecological question with a null hypothesis.

2. Thou shalt so construe their industry in the fields to falsify thy null hypothesis.

3. Thou shalt be duplicate, yeah verily even triplicate, in all that thou dost.

4. Thine industry shall be offered to the statistical priests to receive blessing thereof.

5. Thy labors shall be artful both in the fields and in thy cell.

6. Thou shalt make thyself safe against the cunning of the devil who is called pollution.

7. Thou shalt not seek before the question for it is in vain.

It is possible to both agree and disagree with each of the above depending upon your particular scientific persuasion. Also I'm sure that new commandments could be generated on the spot.

Within this room is an impressive assemblage of experts and expertise. We are gathered here to exchange information and specify our concerns for development of the Eastern Gulf. Hopefully, from the workshops will result a plan and a methodology for providing the needed information. This plan should be phased to accomplish two goals--the short-term needs for exploratory drilling and the longer range needs specified earlier. It may be helpful to mention a few specific needs that require a technical or a scientific resolution.

> The platforms will discharge large volumes of brine which may be of low water quality. Salinities will be high and dissolved oxygen may be low. Will this have a significant impact at the immediate release point or on the system as a whole? What discharge limits, if any, should be imposed?
>
> Drilling muds and other materials may be discharged. What level of control, if any, is needed to protect benthic organisms?
>
> Drilling activities may form blockages to migratory species. Can activities be regulated by variable operation schedules for instance, to assure passage?
>
> Reef areas in the Eastern Gulf are highly productive and some platforms will undoubtedly be placed in positions that may affect these assemblages. Can deep reef systems in the Gulf be studied with available tools? Can they be studied quantitatively?
>
> Is the current state of knowledge relative to hydrology and meteorology adequate to predict the time and place of landing of a spill?
>
> Which dispersants, if any, should be used at which time?

These are some of our concerns in question form. We need your help in framing answers or suggesting what studies must be initiated to provide the technical basis to provide answers. Ten years from now will MAFLA represent the model of how to, or how not to do it? In a real sense it is up to the people at this conference!

Geological Survey's Contributions to Ecosystems Research

Roland von Huene
U.S. Geological Survey
Washington D.C.

The Geological Survey's program of marine environmental research is an outgrowth of long-standing programs such as the cooperative Woods Hole Oceanographic Institution/U.S. Geological Survey investigations that started more than ten years ago. Various divisions of the Survey are involved. The Water Resources Division, in addition to its program monitoring stream discharge, has been involved in developing numerical modeling of Tampa Bay. An interesting highlight of the Division studies off Florida is the research on a submarine spring south of Tampa where waters of anomalous temperature, and possibly with high, heavy metal content have been found. The Conservation Division regularly monitors offshore drilling and enforces the environmental regulations that limit discharge of possible pollutants. The Geologic Division is mainly involved in topical research studies. One area of concentration is in three Texas lagoons local to the regional office in Corpus Christie. A reconnaissance geochemical study was reported not long ago which contains the results from studies of samples taken along the Florida shelf. Recently, an intensive study of geological hazards along the Mississippi Delta has been started. Also related to environmental problems are the regional studies of geologic structure. The Gulf of Mexico reconnaissance study published in a recent professional paper is being followed by a compilation of all available data on geologic structure. Within a year, a regional tectonic map should be available.

These efforts are but a small part of the total program that was planned but which could not be carried out because of the recent national under-funding in science. The most complete Geological Survey multi-disciplinary ecosystems study is in San Francisco Bay. It is a model of studies that were also planned for the Gulf of Mexico and the Atlantic coast. Two significant results of our experience with the San Francisco Bay project are in the area of communications. First, the problem of interdisciplinary communication has been greatly alleviated by housing all scientists in the same building and allowing them to work in adjacent laboratories. The San Francisco Bay team also works together on a single ship, and to a great extent, on the same material. A second area of communications where gains have been made is between the scientists and the local public. The numerous public appearances by scientists from the San Francisco Bay project have been highlighted last year by 99 talks and lectures in the local area. The effects of involvement with the local communities is now beginning to pay off as shown in recent actions by municipal governments and the state legislature. One of the aspects of

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environmental work often overlooked is the socio-political length between the scientist and the public, which is essentially the link between scientific information and its utilization.

One great concern that most scientists have is that with great national pressures for development of OCS oil and gas resources environmental concern will lessen or be brushed aside. Encouraging, however, is the step that the Office of Management and Budget has just made by recognizing an OCS management responsibility that includes funding of adequate environment research. The MAFLA area is the first to receive such funding. Since a good understanding of the MAFLA ecosystems is a task that will challenge our collective abilities, the whole scientific community has a charge to work quickly and effectively toward this goal.

NOAA's Role and Responsibilities
With Respect to Outer Continental Shelf Development
in the Eastern Gulf of Mexico

Allan Hirsch
NOAA/Marine Ecosystems Analysis Program
Washington, D. C.

The National Oceanic and Atmospheric Administration's interests and responsibilities in baseline investigations of the N. E. Gulf of Mexico with respect to the forthcoming offshore development stem from two basic NOAA missions. These are:

1. Management and protection of marine resources.
2. Survey, study and analysis of the marine environment.

With respect to management of marine resources, NOAA's responsibilities include those of the National Marine Fisheries Service relating to fisheries resource management, including important responsibilities under the Fish and Wildlife Coordination Act for advising on federal actions which could alter the environment. Environmental considerations are also involved in administration of the Marine Mammal Protection Act of 1972. NOAA also administers the Coastal Zone Management Act, which provides funding for development and implementation of state coastal zone management programs. Under this legislation, the Department of Commerce, through NOAA, has a very important role in coordinating the views of federal agencies concerning proposed state coastal zone management programs and in providing federal approval for such programs. Another recent responsibility involves the authority to designate Marine Sanctuaries under the Marine Protection, Research and Sanctuaries Act of 1972. In this regard, it may be of interest to know that NOAA is already working with the Bureau of Land Management to consider possible designation of the Flower Garden Reefs in the Western Gulf of Mexico as a Marine Sanctuary.

A second category of NOAA responsibility relates to the agency's scientific and technical mission of surveying, studying and understanding the marine environment. A wide range of NOAA programs and components are engaged in this mission. These include such activities as the research programs of the Atlantic Oceanographic and Meteorological Laboratories in Miami. That laboratory, together with the Southeast Fisheries Center of the National Marine Fisheries Service in Miami, the Gulf Coastal Fisheries Center in Galveston, as well as other NOAA scientific and technical facilities such as those at the Mississippi Test Facility all combine to provide a very strong NOAA scientific capability in the Gulf region. The National Ocean Survey with its tide-and-current work and Mapping activities is yet another example of a NOAA component whose mission relates directly to the problem at hand. The Environmental Data Service, with its marine environmental data management responsibilities also plays an important role, as do other NOAA components. Representatives. of several of these NOAA activities will be speaking on the program at this workshop.

These various responsibilities give NOAA a key interest and role in the problem we are gathered here to address today. NOAA's position can be summarized as seeking a balanced approach to the development of offshore resources. The need for development of these resources in relation to the Nation's energy requirements is well recognized. However, existing scientific information on the marine environment is inadequate, and additional studies are essential if we are to maintain a balance between offshore development and environmental protection.

I believe that we--not only the representatives of the federal agencies, but representatives of other levels of government, academic institutions and industry--have a real responsibility to design and conduct environmental studies which will assure that we can detect, predict and prevent environmental damage. As a member of the Inter-Agency Management Committee working with the Bureau of Land Management and other agencies to design studies of the N. E. Gulf of Mexico lease area, NOAA's principal concern is to assure that these studies will be adequate to that end.

Among the elements we believe must be stressed are the following:

1. Because of the very tight time constraints dependent upon the drilling schedule, we must distinguish between those studies that must get started now and those that can await design of a more orderly, fully comprehensive environmental study effort.

2. Priorities must be established. We must identify those observations that should receive early and immediate attention because they represent parameters that are likely to be impacted or to be indicators of impact. We must identify and quickly measure those things that are likely to change. Physical transport mechanisms are not likely to change as a result of drilling activity, but the hydrocarbon levels in various organisms may.

   Thus a constant theme throughout the workshop's discussions ought to be to address these short-term, pre-drilling baselines. We must ask, what should be measured? how should it be measured? where should it be measured? when should it be measured?

3. An integrated study design must be formulated, and that design must be addressed to the issue at hand--namely the environmental impact of drilling and associated development. The opportunity for conducting baseline studies cannot be used as an excuse for a series of studies--

however well conceived and important scientifically--which are not addressed to that issue. At the same time, the studies that are done must be scientifically sound, and not merely expedient.

4. Ways must be found of making available and utilizing existing data, both to assist in environmental analysis and interpretation, and for the purposes of formulating study designs.

5. Appropriate means of calibration and quality control must be applied if the data collected are to be meaningful. For example, many scientists and laboratories claim the capability to do hydrocarbon analyses, but probably very few can provide such analyses on a truly reliable and comparable basis. In fact, we might think of the proposed baseline studies as an incomparable opportunity for collecting non-comparable data unless we are very careful in this regard.

6. Last, I would stress the importance of a systematic data management process. We must be able to archive and retrieve and manipulate the vast array of data which will be collected.

These are the points that we will be working toward as this study effort unfolds. We look forward to receiving the views and advice of the many scientific experts present at this workshop on these points.

Navy's Oceanographic Program and Offshore Technology

L. M. Riley
Office of the Oceanographer of the Navy
Alexandria, Virginia

The U.S. Navy exists because the Ocean is there. If the Navy is going to be effective in its mission, we have to know what there is about the ocean that affects our operations. The purpose of Navy oceanography is to get that knowledge as quickly and as efficiently as possible and to convert that knowledge to technology for enhancing operational effectiveness. We've been at the job longer than most others, and because we were first, we have developed new meanings for the word"oceanography."

The Navy has always needed to know about water depth, currents, waves, and changing weather patterns. As our operational systems become more sophisticated we need more detailed information about the marine environment. Our concept of oceanography has changed in the past 30 years or more, and we have learned that we cannot design new systems to operate in the ocean without understanding exactly how the environment affects their operation. New system concepts have come out of better understanding of the ocean environment, and at the same time, better understanding of the environment has generated new systems requirements.

The Navy is the dominant user of the sea. While many others also use the sea, the Navy is involved from its surface and its interface with the atmosphere down to the ocean floor. Of all United States federal agencies, only the Navy uses all the products and services it develops in its ocean programs. Other federal agencies support ocean programs that provide oceanographic services to other users. The Navy is in the business to improve its operational capabilities and to broaden its options for response to totally ocean-oriented responsibilities.

I would like to illustrate, by a description of the Navy's oceanographic program, how the Navy's efforts have expanded the meaning and objectives of oceanography for the Navy and for the Nation. Our achievements in oceanography serve a double purpose of supporting the Fleet and providing a base of knowledge upon which civilian programs in the oceans are able to build.

The Navy's oceanographic program is divided into four major categories of activity: ocean science, ocean engineering and development, oceanographic operations, and environmental prediction services.

The program is funded this year at nearly 200 million dollars, which represents about one third of the national dollar commitment to

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ocean programs. Two-hundred million dollars for Navy oceanography does not include the cost of environmental research and development of combatant ships, aircraft, or submarines...nor the operational cost of our significant deepsubmergence program...nor salvage and diving. For example, we have nearly 4,000 Naval personnel performing as divers, and this capability costs approximately 40 million dollars annually.

There are many other projects that are really oceanographic in nature that are not included in the advertised Naval oceanography program, because they are a specific part of a weapons systems development program.

The Navy ocean science program includes physical, chemical, and biological oceanography; marine geology and geophysics, and underwater acoustics.

Acoustic research is concerned with the identification and evaluation of the many ways sound can travel from a source to a receiver in the sea. We need precise information about how the water and its basins influence the transmission of underwater sound so that we can either overcome, or employ, those effects in our ocean operations.

We support studies of the geology of the ocean basins and of the interface between land and sea to support amphibious and undersea operations.

We conduct biological investigations to help us understand more about living organisms in the sea and how they influence the performance of operational systems.

We support a great number of scientific projects investigating the oceans which are conducted for the Navy by way of contracts with both private industry and academic establishments. Our oceanographic research ships, operating from both our Navy laboratories and from academic institutions, are in operation around the globe collecting data on and conducting investigationa of the marine environment.

An essential part of our oceanographic program is biomedical research, working on the potential and the limitations for human activity in the ocean. Experiments in diver-physiology include studies of exotic breathing gases, hearing loss, loss of body heat and damage to bone structure.

Another major program area in Navy oceanography is the ocean engineering and development program. Our objectives in this program are to provide the capabilities for the Navy, and the Nation, to operate effectively anywhere in the world's oceans, at any time and at any depth. The Navy's defense responsibilities do not terminate at two or twenty or even two hundred feet below the surface of the sea, but are projected throughout the total ocean environment. If we can operate at 20,000 feet, we can cover about 95 percent of the ocean floor.

Our ocean engineering and development program has produced two deep submergence rescue vehicles, (DSRV), with capabilities for descending to depths of 5,000 feet. The DSRV can be airlifted across great distance and once at the scene of an emergency descend to mate with a disabled submarine's escape hatch lifting as many as 24 crewmen to safety at a time. This is a military capability that could be made available to civilian submersibles if their hatches were designed to fit the DSRV system. The plans are available.

The Navy's large object salvage system project investigates methods for lifting sunken ships, downed aircraft, or other large objects of value from the sea floor. One of several methods being developed uses new, controlled gas generation techniques to inflate lifting pontoons for bringing attached objects to the surface.

The Navy has developed a highly professional salvage capability which is one of the best in the world. It is the policy of the Navy, as directed by the Congress, to salvage other than Navy ships or aircraft when adequate privately owned salvage facilities are not readily available.

The Navy's deep ocean technology project is giving us much of the basic technology needed to do useful work in the ocean. The sea construction experiment, for example, brings together in one project many investigations of materials and fabrication techniques for underwater construction using primarily concrete materials.

We also need to know the engineering properties of marine sediments for supporting underwater structures.

From the deep ocean technology project has come the cable-controlled underwater recovery vehicle capable of unmanned recoveries to depths of 7,000 feet. It is equipped with cameras, lighting, and work instruments for remotely controlled search of ocean floor areas and retrieval of objects from the sea floor.

Since there is no ready-made ocean technology available to the Navy or the Nation, we are building it almost piece by piece. We need, among other things, new materials to withstand the great pressure and corrosive action of the deep ocean. Advanced steel and titanium alloys are new developments being considered for prospective use in submarine hulls. Transparent materials, such as acrylics and glass, are being investigated in a number of experiments for use in submersible hulls. Power sources of several kinds (nuclear isotope, fuel cell, sea water batteries, to name a few) are under study for electrical power up to 5,000 kilowatts for heavy work in the deep ocean.

A remote, unmanned work system is being developed to perform remote-controlled operations to depths of 20,000 feet in the sea. It will be equipped to operate remote control snap-in, snap-out modular working tools.

We have developed the Mark II Deep Dive System consisting of a deck decompression chamber, a personnel transfer capsule, and a control console for saturated (helium-oxygen) diving operations. The Mark II Deep Dive System is capable of supporting eight divers continuously, for rescue and salvage work, for up to ten days. Divers operating from the Mark II system established an international open-water diving record of 1,010 feet.

Supporting the U.S. Navy's efforts to develop an effective ocean engineering capability is a highly efficient laboratory system operated by the U.S. Navy. This laboratory system is unique in its ability to respond to requirements for Navy and national ocean programs. One of these, the Naval Coastal Systems Laboratory located at Panama City, with its two offshore research towers, Ocean Pressure Simulation Facility, (OSF), computer complex, and other excellent facilities, is the largest technological research and development center in Florida.

A third major program area in Navy oceanography is oceanographic operations. In this area we have just gone through a major change in organization and placement of responsibilities. By executive order in November 1971, President Nixon established the Defense Mapping Agency, thereby transferring historic responsibilities for the production and distribution of worldwide nautical charting and navigational materials from the Navy to the new mapping agency. No longer does the U.S. Navy produce worldwide nautical charts and other navigational material for mariners. However, we still maintain an active interest as the hydrographic and oceanographic ships, aircraft, and survey personnel remain with the Navy, and the Navy continues to collect the worldwide ocean data necessary for the Defense Mapping Agency to do its job.

It is inherent in the mission of the Navy to improve its understanding of the marine environment. In both peace and conflict, the Navy is charged with readiness to defend our Nation's security with the best sea power capabilities we can devise. We are required by the responsibilities of that mission to lead the way into exploration and development which is of limited interest to others.

The Navy recognizes responsibility for transferring as much of its oceanographic achievement to national efforts in the ocean as it is possible to share, without compromising military advantage. An orderly transfer of Navy-developed ocean science and technology to the civilian economy is recognized by the President, and fully supported by the Chief of Naval Operations and the Secretary of the Navy, as serving the best interest of our Nation.

The need for oceanographic products and services will undoubtedly increase as our Navy's operational systems become more sophisticated. Most of what we do to support that growth in requirement will be of use in all national programs in the oceans.

Our Naval oceanographic program is capable of serving both military and civilian requirements as we develop Naval capabilities for useful work in the oceans.

Florida Coastal Zone Environmental Considerations as Related to Petroleum Exploitation in the Eastern Gulf of Mexico

James I. Jones
Florida Coastal Coordinating Council
Tallahassee, Florida

The Florida Coastal Coordinating Council was created by the Florida legislature in 1972 to provide a focal point within the government of Florida to deal with problems of the coastal zone. Four primary charges were mandated in that legislation:

1. to develop a comprehensive state plan for the protection, development, and zoning of the coastal zone, making maximum use of any federal funding for this purpose;
2. to conduct, direct, encourage, coordinate, and organize a continuous program of research into problems relating to the coastal zone;
3. to review, upon request, all plans and activities pertinent to the coastal zone and to provide coordination in these activities among the various levels of government and areas of the state;
4. and to provide a clearing service for coastal zone matters by collecting, processing, and disseminating pertinent information relating thereto.

Within the context of these broad charges the Coordinating Council has moved rapidly forward in matters of coastal zone management and recommendation. In recognition of the lead role being played by this organization in matters relative to the coastal zone the Governor and cabinet of Florida have recently named the Council as the sole Florida agency responsible for the program development and management and expenditure of funds relative to the National Coastal Zone Management Act of 1972. Further information on the development, goals and achievements of the Council are contained in the hand-out, which is available.

Florida's coastal zone consists of 27,660 square miles, and includes 75 per cent of Florida's population. Estimates indicate that by the year 2000 some 10,000,000 permanent residents will make their homes within the coastal zone, and several times that number will occupy it at varying times each year as tourists. Surely, a resource of such magnitude requires a high level of effort relative to management, control, and planning. It is the primary charge to the Council to provide the leadership and the mechanisms essential to the management of this region.

Since there is a clear designation that protection, development, zoning, research, and coordination of these activities within the coastal zone are the obligation and responsibility of the Council, it is appropriate that many of the complex problems attendant to outer continental shelf petroleum development are the real and legitimate concern of the Council. Because of this I have participated in the organization of this conference/workshop, and it is in regard to this that I speak to you today.

While it is inappropriate to develop a detailed discussion relative to the environmental aspects of the eastern Gulf of Mexico OCS area, since that is indeed a purpose of this workshop, nevertheless a delineation of what I feel are the more critical concerns relative to this area should be included in this short presentation. It is essential that a concerned industry, monitored, and to a degree controlled, by appropriate state and federal agencies, use every means available to modern technology to limit and ameliorate the effects of the OCS activity upon the area of development. Such means would logically include, in addition to technological advances, a comprehensive baseline evaluation and subsequent monitoring program in all areas of activities. Such a comprehensive baseline evaluation should be made for the total eastern Gulf since the environmental health of the total eastern Gulf ecosystem may be at stake in the proposed developmental operations. Research activities should be limited to only those applied aspects which prove to be essential. Time may provide the opportunity for the luxury of investigations which do not have immediate or easily recognizable application, but these should not be attempted within the time and budgetary constraints imposed upon the present program. Additionally, it is imperative that information which has already been collected, whether analyzed or not, be made available in the shortest possible time, for evaluation of the historical environmental aspects of the area.

Examples of such studies include the HOURGLASS program of the Florida Department of Natural Resources which contains significant unreduced and unevaluated information, and the EGMEX and Western Florida Continental Shelf programs, data from which are being analyzed through the State University System of Florida Institute of Oceanography and others. Many other examples of completed studies, the results of which are not readily available to current investigators, could be cited. All such studies should be completed, and the information from them incorporated into an easily retrievable storage system, to be used by all concerned investigators, as they may be required. Funds for these types of activities should be provided at the onset of the program, as completion of studies with subsequent data availability has a very high priority.

It is imperative that each area which will be impacted by the effects of exploration activity be "measured" from all significant environmental aspects so that environmental change in these areas, in response to the develcpmental exploration activity may be documented. Only through such documentation may potential legal problems which could develop from the activity be satisfactorily resolved. State concerns, while predominantly involved in the inshore or territorial seas of Florida, do indeed extend to the offshore area as well, since nature does not recognize the artificial boundaries imposed upon her by man. The State of Florida, through the Coastal Coordinating Council, requires that a number of environmental guarantees be provided by the Federal Government and petroleum industry. Florida recognized the importance and the inevitability of development of her offshore resources. We do require, however, that such development be only allowed or encouraged within the context of the most stringent regulations and safeguards. Florida has, more than any other Gulf of Mexico or eastern state, a unique and highly fragile coastal environment. This environment is, in turn, responsible for the major resource of the State--that of tourism. We cannot, indeed will not, gamble unrealistically with this resource. That a gamble exists in the form of any type of offshore petroleum development is apparent. Whether or not this gamble becomes unrealistic will, to a great part, be determined by the deliberations and proposals developed in this conference and workshop. Let us hope for Divine guidance to resolve the difficult and often frustrating problems which we are to face, and in the absence of, or in addition to Divine intervention, develop the most stringent safeguards and environmental requirements that any state or other governmental entity has yet proposed. Such control, with attendant safeguards may preserve enough of what we love of Florida so that it will continue to be desirable for generations to come.

Finally, I would like to recommend, for your consideration, the develment of an outer continental shelf environmental authority. Such authority should consist of a number of professionals, encompassing a broad range of environmental and technological expertise, to act as the primary coordinative group in regard to OCS environmental problems and activities. This group should be composed of individuals from state, federal, and private organizations and groups and should have both a recommendatory and regulating responsibility. By working in cooperation with federal and local permitting and regulatory agencies it could expedite permitting at those levels. Additionally, it could provide the very necessary immediate reaction capability essential to changing developments relative to the environmental health of the OCS and coastal zone. The detailed structure and responsibility of such a group should be the topic of a conference and workshop other than this, but I request endorsement of this concept, in whatever form it need take by the persons available here. Further, I shall work toward the development of such a group, in cooperation with interested persons represented here and others, to be able to provide you a study and evaluation plan for your early consideration.

It has been a privilege and honor to have had the opportunity to address you. I hope that in our meetings and deliberations in the next two and one-half days we can develop an appropriate working plan leading to initiation of studies and activities which will allow the development of a much needed energy resource, with minimal damage to our environment. If we fail in this objective, with history as our judge, we will surely have failed the succeeding generations of Floridians, as yet unborn, who are unknowingly dependent upon our wisdom and ability during this crucial and difficult period for mankind.

Legal Aspects of Resource Exploration and Exploitation in the Eastern Gulf of Mexico

Dennis M. O'Connor
Program of Ocean Law
University of Miami
Coral Gables, Florida

Editor's Note: For information pertaining to the presentation, please contact:

Mr. Dennis M. O'Connor
Program of Ocean Law
School of Law
University of Miami
Coral Gables, Florida 33124

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An Overview of the Petroleum Industries Marine Environmental Research

Edward W. Mertens
Fate of Oil Task Force
American Petroleum Institute

It is my pleasure to present to you this morning a report on the efforts of the petroleum industry to study the fate and the biological effects of oil spilled in the marine environment. My comments will pertain primarily to the research work supported by the American Petroleum Institute, especially the program that is under the sponsorship of the Fate of Oil Task Force. However, before I discuss this program, I shall comment briefly on other marine environment research programs that are also funded by the petroleum industry.

Perhaps the largest of these other programs is that being conducted by the Gulf Universities Research Consortium (GURC). This program, which is coordinated by Dr. James Sharp, is a two-year program at the funding level of about $750,000 each year. GURC is well into the second year of their effort. Their program includes such diverse topics as water column measurements, which include current direction and velocity, temperature, salinity, density fields, toxic trace metals, nutrients and turbidity. In their work on hydrocarbons, they have projects concerning hydrocarbon concentrations in water, sediment and biota; identity and source of environmental hydrocarbons; and organic carbon distribution in the water column. Their sediment studies include impact of drilling operations; distribution and origin of bottom sediments; trace metals in sediments; identity and extent of cuttings; organic matter in sediments; and hydrocarbons in sediments of beaches, bays, and offshore. Studies involving the effects of platform on biota include pre-platform and post-platform fish concentrations; recorded oil spills in the area; primary production; zooplankton consumers; amphipod distribution and concentration; polychaete distribution and concentration; fouling communities and platforms; grazing and reef effects; seagrasses and algae; interstital fauna, oyster and sand beach communities; birds and mammals; microbial degradation of oil spills in the area; and the impacts of the natural Mississippi River plume and of its flood stages.

In addition, as a result of the petroleum industry's interest in developing offshore superports in the Gulf of Mexico, marine environmental research has been funded. This work for Seadock, the proposed superport near Galveston, Texas, is contracted for approximately a half-million dollars to Dames and Moore, who are conducting the land and meterological studies. The marine studies are subcontracted to Texas A & M University.

Similar studies are being conducted for the proposed Louisiana

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Offshore Oil Port (LOOP). This work is being done by Louisiana State University and Nicholls State University.

In an entirely different area, considerable work has been underway for nearly three years in the American Society for Testing Materials (ASTM) Committee D-19 "Identification of Water Borne Oils." Governmental agencies, the academic community and industry are represented in nearly equal numbers. This committee is comprised of eight or nine panels, each of which is striving to develop standard methods in their respective areas of responsibility. Examples of such areas include sampling; analysis of hydrocarbons in the water column, in sediments, and in marine tissues; and other topics.

One of the activities of the American Petroleum Institute (API) is the work being done under the sponsorship of its Subcommittee on Fish, Wildlife and Conservation. Just recently, under API's sponsorship, State University System of Florida Institute of Oceanography (SUSIO) completed a study in which an inventory was made of the various aspects pertaining to the marine environment of the Eastern Gulf of Mexico. This API Subcommittee also sponsored a similar study pertaining to the Atlantic Coast from Cape Hatteras to Nantucket Shoals at the University of Rhode Island. This study is also completed and the final report is available.

Before I spend my remaining time describing the major activities of the API Fate of Oil Task Force, I shall comment briefly on the industry's overall environmental efforts.

For the period from 1966 to 1972, the industry, primarily directly by its member companies, has invested 4.4 billion dollars on protection of land, air and water. As a consequence, all our operations, whether they be in production, transportation, refining or marketing, are having much less impact on the environment through discharges of contaminants that could result from these activities than if this expenditure for research and equipment had not been made. For 1972 alone, the reporting member companies -- which comprise about 80 percent of the refining capacity in our country -- spent $596,000,000 on air conservation; $480,000,000 on water conservation; and $124,000,000 on land conservation. The cost of environmental protection equipment on new capital refining facilities is approximately 10 percent of the total cost of the facilities.

I regret that time did not permit me to report in greater detail these environmental activities sponsored by the petroleum industry that I've mentioned so far. However, the work of direct interest to you under the sponsorship of the API Fate of Oil Task Force, which I will now discuss, will be described somewhat more completely.

The Task Force is comprised of 15 members working within the petroleum industry. The various subordinate panels are staffed by these members augmented by nearly a like number of other petroleum industry personnel. The Task Force and its panels are assisted by four people from the American Petroleum Institute staff. Consultants, usually drawn from academic institutions, assist our Task Force and its panels. Among the industry and staff members are represented such diverse disciplines as doctors of medicine, toxicologists, public health specialists, marine biologists, microbiologists, wildlife specialists, mathematicians, physicists, physical chemists, analytical chemists, petroleum chemists, and petroleum engineers.

Research problems are defined at the Task Force level, often with the assistance of one or more of the panels. About April 1 of each year the Task Force develops a recommended research program for the following year. Priorities among the several proposed projects are established with the estimated cost of each project. Each of the projects in our proposed program is reviewed critically by higher American Petroleum Institute committees responsible for the overall industry-sponsored research program.

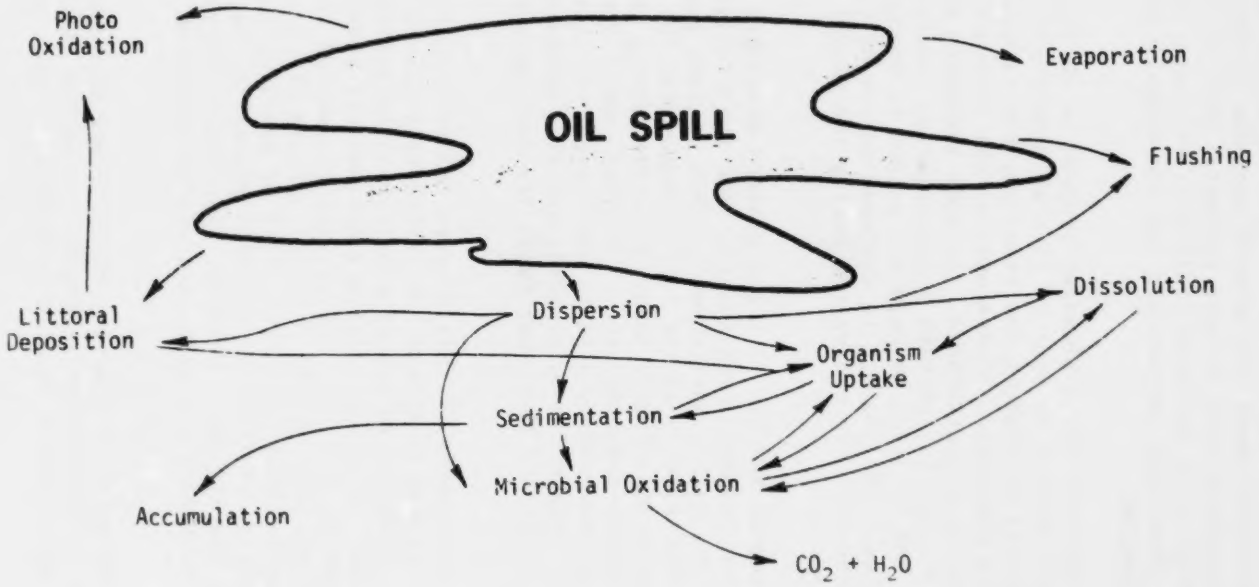
Once approval for a proposed project is obtained, a description of the proposed project is sent to several potential contractors known to have capability to conduct the research that is needed. Proposals are received and evaluated. Subsequently, the contract is awarded to one of the responding contractors. In some instances this procedure is shortened by negotiating with a pre-selected contractor who by previous experience and location is uniquely suited to conduct research on a specific problem. The project is assigned to one of the panels which maintains liaison with the contractor during the course of the contracted research project.

Our program results from the concern developed in recent years by the petroleum industry over the fate and the biological effects of oils spilled in the marine environment. This concern was prompted by some major oil spills, such as the Torrey Canyon and the Santa Barbara spills, and by speculation of many individuals concerning the effects of such spills on marine organisms and on people. We in the petroleum industry reviewed the knowledge available and determined that there was a real lack of hard scientific information and that inadequate research was then being conducted to answer fully the many important questions in this area.

As a consequence of this concern and effort, in recent years the American Petroleum Institute has funded research on the fate and effects of oil at a level in excess of a half-million dollars per year. We expect that this level will continue for several years. For this year our budget is nearly $675,000. It is well to mention that in addition to our current projects on the fate and effects of oil, other programs are being funded to determine better ways of handling and transporting oil to avoid spills. Effective oil spill prevention is, of course, the best solution to the oil spill problem. Thoroughly trained men and properly maintained equipment are also part of the petroleum industry's overall effort.

The complexity of studying the fate and biological effect of spilled oil is illustrated in Figure 1. As the diagram shows, once oil is spilled its ultimate fate is determined by such processes as

FIGURE 1
SOME FACTORS WHICH INFLUENCE THE ENVIRONMENTAL
EFFECTS OF EPISODIC OIL SPILLS


OIL SPILL
Photo Oxidation
Evaporation
Flushing
Dissolution
Littoral Deposition
Dispersion
Organism Uptake
Sedimentation
Microbial Oxidation
Accumulation
CO_2 + H_2O

(Courtesy of Battelle Memorial Institute - Northwest Laboratories, Richland, Washington) evaporation, photooxidation, dispersion, dissolution, deposition along shorelines, accumulation in sediments, microbial degradation, and last but not least, uptake by the myriad organisms that comprise the marine community in any given locale.

In our first effort we funded an exploratory project at Battelle-Pacific Northwest Laboratories to examine the potential threat of spilled oils to marine life. Several oils, including a highly aromatic No. 2 fuel oil, were used in this study. Each of these oils was used with and without a dispersant. The various life stages - i.e., the egg, larvae, juvenile, and adult forms - of several molluscs, crustacea, and fin fish were exposed to the several oil and oil-dispersant systems. In addition, studies involving phytoplankton were also conducted. Observations made were those of immediate lethality; long-term, sublethal effects resulting from a single exposure; effects from chronic exposure; and whether or not evidence of carcinogenic properties existed.

As a consequence of their research, Battelle-Northwest has presented several papers pertaining to phytoplankton studies, development of new bioassay techniques, and development of improved chemical analysis for oil in the marine environment at both the 1971 and 1973 Joint Conference on Prevention and Control of Oil Spills. In addition, they have submitted two major reports to the American Petroleum Institute. These reports entitled "Regional Survey of Marine Biota for Bioassay Standardization of Oil and Oil-Dispersant Chemicals" and "Effects of Oil and Chemically Dispersed Oil on Selected Marine Biota - A Laboratory Study" are publicly available from the American Petroleum Institute.

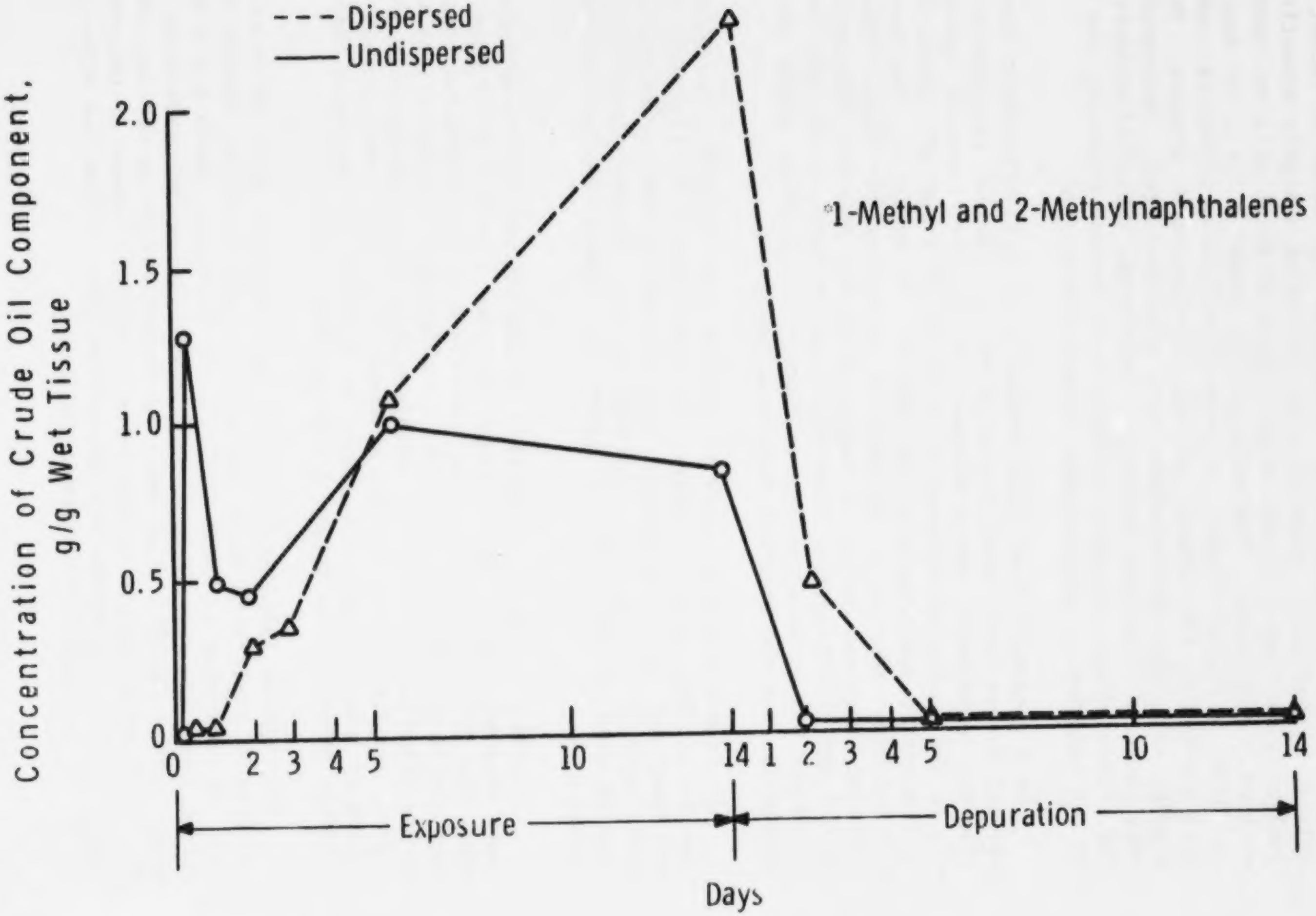
It is not possible today to provide even a cursory review of the results of their work. However, it is worthwhile to highlight one of the important findings, namely, that concerning the uptake and subsequent rapid purging of a typical component of oil, the methylnaphthalenes, by oysters when exposed to Kuwait crude oil. These results are shown in Figure 2.

As shown in Figure 2, oysters accumulate and retain methylnaphthalenes when exposed to Kuwait crude oil over a period of 14 days. However, the oysters quickly purge themselves of the petroleum components when placed in oil-free seawater. A widespread concern exists that marine organisms concentrate petroleum fractions indefinitely and pass them up the food chain in such a manner that they pose a threat to the health of human beings. It cannot be stressed too strongly that the evidence presented in Figure 2 negates this concern.

Even before Battelle-Northwest has completed their projects, verification of their work by an independent contractor was deemed imperative. Thus, as indicated in Table I, Dr. J. W. Anderson, Texas A & M University, was assigned the responsibility of corroborating this extensive work under Project OS-20C. This two-year investigation is nearing completion. His final report should be available during the summer of this year. Significantly, his uptake and depuration data confirm the principle observed in the Battelle-Northwest studies.

FIGURE 2

THE UPTAKE AND RAPID PURGE OF
KUWAIT CRUDE OIL COMPONENTS* BY OYSTERS



*1-Methyl and 2-Methylnaphthalenes

A small field study entitled "Oyster Studies" was initiated this year by Dr. Anderson to complement his laboratory research. This project, identified in Table I as OS-20J, will be absorbed next year by a much larger project under Dr. Anderson's direction. This project, identified as OS-20P, will be entitled "Field Study, Effects of Oil." Dr. Anderson's field work is too recently implemented to provide data from which even tentative conclusions could be drawn at this time. Also nearing the end of a two-year investigation is a project entitled "Natural Chronic Exposure Studies." The principal investigator is Dr. Dale Straughan of the Allan Hancock Foundation at the University of Southern California. A major objective of Dr. Straughan's work is to determine in a natural chronic exposure area whether the incidence of growth irregularities in local biota is unusually high. Dr. Straughan conducts her studies in the marine waters at Coal Oil Point near Santa Barbara, where natural oil seeps have persisted for a countless number of centuries. Her test organisms are those living in their normal habitat in that area. To date, Dr. Straughan finds a complete absence of abnormal growth in the local biota. Her completed report should also be available sometime this summer.

We are also sponsoring a project "Fate of Oil in Water Environment" with Dr. R. L. Kolpack of the Department of Geological Sciences at the University of Southern California. He and his colleagues are developing mass balance relationships to account for the evaporation, dissolution, sedimentation, and biodegradation of oil. In the first phase of this work, identified as Project OS-20F, Dr. Kolpack's team conducted an exhaustive literature review on this subject. Their report should be available by this spring. In their second phase, now under way, they are examining the known data to determine the areas in which information is inadequate. If this project is continued, the third phase will be research to fill in the "holes" identified in Phase Two.

Another project that commenced late last summer is Project OS-20I, "Natural Biodegradation Studies." This work is being conducted under the direction of Dr. Rita Colwell at the University of Maryland. The purpose of this project is to define more clearly the biodegradation process by using very careful techniques of chemical analysis.

Yet another project is OS-20L entitled "West Falmouth Spill Survey." Dr. A. D. Michael of the Marine Biological Laboratory located at Woods Hole, Massachusetts, is following the recovery of the spill that occurred at nearby Buzzard's Bay in September, 1969. After a summer's work, Dr. Michael is now evaluating his data. A second year's support of this study has been funded.

Underlying all these projects is a strong emphasis on chemical analysis of petroleum fractions found in the water column, the sediments, and the tissues of the marine organisms. With the exception of the Battelle-Northwest research, the extensive supportive chemical analytical work has been conducted by Battelle Memorial Institute located at Columbus, Ohio. In addition to performing this highly sophisticated analytical work, Dr. J. S. Warner and his associates have developed new analytical techniques under Project OS-20N as the need for these techniques has developed. In devising these new techniques, Dr. Warner's team has received immeasurable assistance from the Task Force's Chemical Analysis Panel, which is composed of six chemical analysts recruited from the petroleum industry. These analysts were carefully selected for their recognized expertise in their respective areas of specialty. Indeed, through the Chemical Analysis Panel a level of competency in chemical analysis work is provided each of our contractors that cannot, without exception, be duplicated by any other investigator, research team or institution. Lastly, a project will be initiated early in 1974 by the Esso Research and Engineering Company to develop analytical methods for those highly complex petroleum fractions described as polynuclear hydrocarbons. This project is identified as OS-20Q.

On behalf of our Task Force, I wish to express our appreciation for the opportunity today to discuss our program with you.

Data Management - Sensor to Center

Robert V. Ochinero
NOAA/Environmental Data Service
National Oceanographic Data Center
Washington, D. C.

The Environmental Data Service (EDS) provides dynamic and total data and information management for the National Oceanic and Atmospheric Administration (NOAA) of the Department of Commerce as well as to all other components of the oceanographic community.

The EDS is comprised of five centers--three centers deal primarily with digital and analog data, one with scientific literature and information, and one in the unique position between the researcher and national repository, but much more directly involved in the research effort than any of its four sister centers. The centers involved with digital data are:

> The National Climatic Center (NCC) located in Asheville, N. C. Repository for climatological data collected by the National Weather Service, the Weather Services of the Air Force and Navy, and the thousands of voluntary observers scattered throughout the nation.
>
> The National Geophysical and Solar-Terrestrial Data Center (NGSDC) located in Boulder, Colorado. Repository for marine geological and geophysical data, as well as data from solar activity, interplanetary phenomena, the ionosphere, cosmic rays, aurorae and airglow data.
>
> National Oceanographic Data Center (NODC) located in Washington, D. C. Repository for physical/chemical data, biological data, pollution data from the world's oceans.
>
> The Environmental Science Information Center (ESIC), located in Washington, D. C., is concerned primarily with scientific and technical literature and information as well as handling the publishing and library responsibilities for NOAA.
>
> The Center for Experiment Design and Data Analysis (CEDDA), also located in Washington, D. C., is the newest element within EDS. CEDDA has been deeply involved with such meso- and macro-scale projects as the Barbados Oceanographic and Meteorological Experiment (BOMEX), the International Field Year for the Great Lakes (IFYGL), the Global Atmospheric

Research Program (GARP) for the Atlantic Tropical Experiment (GATE), and in 1977 will participate in the First Global GARP Experiment (FGGE).

Brochures describing the functions, mission and services available from EDS and its centers are available on request from the Director, Environmental Data Service, NOAA, Washington, D. C. 20235.

For some of you, the "sensor to center" part of the title may be suggestive of the often used phrase, "from womb to tomb". However, it is this image that we in EDS are trying to dispel. Data management to us does not connote musty, dusty, passive archives presided over by that proverbial old lady in tennis shoes. Based on EDS' experience in Project Data Management for such programs as the National Science Foundation's International Decade of Ocean Exploration (IDOE), Cooperative Investigations of the Caribbean and Adjacent Regions (CICAR), NOAA's Marine Ecosystem Analysis (MESA) Program, etc., we find that data management is dynamic and comprised of three phases of activity--pre-operational, operational and post-operational.

Pre-operational activities include such things as:

1. preparing the data management portion of the operational plan which provides specifics concerning the data, units, instrumentation and calibration information and flow of data between and among participants and ultimately, to the appropriate data repositories;

2. preparing manuals, such as the Manual on IGOSS Data Archiving and Exchange for the Integrated Global Ocean Station System (IGOSS) of the Intergovernmental Oceanographic Commission (IOC), UNESCO;

3. preparing data catalogs for large-scale projects such as IFYGL and GATE. These planning and coordinating documents provide a detailed index to who is planning to collect what and where and with what instrumentation. Once the project is underway the Data Catalog provides a monthly record of accomplishment; and

4. providing historical data and information already available for the area thus eliminating unnecessary duplication of survey efforts.

Operational activities include:

1. assistance in the processing of data;

2. validation and quality control of data;

3. maintaining a computer searchable file such as the National Marine Data Inventory (NAMDI) which includes information on the who, what, where and when of U. S. collection efforts; and

4. analyses of data and preparation of data products which provide useful feedback concerning the quality of the data.

Post-operational activities include:

1. assistance in the preparation of data products, such as computer graphics, summaries, etc.;
2. accessioning these fully documented data for secondary users; and
3. completing an Environmental Data Base Directory (EDBD) inventory form on those data which, for certain reasons, are not as yet being accessioned by EDS.

By being directly involved in the pre-operational, operational and post-operational phases of projects, EDS truly performs data management activities from sensor to center.

There are a number of EDS products and services available for and applicable to the eastern Gulf of Mexico. Some of these are:

1. "Temperature, Salinity, Oxygen and Phosphate in Waters Off United States, Vol. 2, Gulf of Mexico" (in press; available summer 1974).
2. "Environmental Conditions Within Specified Geographical Regions: East and West Coasts of the U. S. and Gulf of Mexico." April, 1973.
3. "Environmental Guide for Seven U. S. Ports and Harbor Approaches." February, 1973.
4. "Environmental Guide for the U. S. Gulf Coast." November, 1972.
5. "CICAR Bibliography." Volumes I, II, and III.
6. "Inventory of Archived Data." 1969.
7. "Climates of the United States." 1973
8. "Synoptic Summaries of Meteorological Observations."

Services and products available from the NODC are described in "User's Guide to NODC's Data Services."

The EDS does have the data management tools, know-how and experience to organize and manage large products or to assist anyone who might have that responsibility.

I would like to take this opportunity to say a few words about NOAA's Environmental Data Index (ENDEX) program, and more specifically, the Environmental Data Base Directory (EDBD) efforts of this program.

Scientists, managers, decision-makers at all levels of government are increasingly dependent upon and concerned about the amount and quality of environmental data and information available for consideration in the decision making process. Such data are available only if someone other than the local holder of the data file knows of its existence.

The research community is rather well served by its specialized bibliographic and abstracting services. Even "research in progress" is documented at the federal level through the Science Information Exchange of the Smithsonian Institution. In the area of environmental data files, sample collections and specialized sub-discipline reference library collections, it is becoming increasingly important that the existence, scope and documented content of these files or holdings be made more widely known, so that they need not be unnecessarily duplicated and so their content may be more widely appreciated. Holdings, in many cases, are inventoried, indexed, and even documented on a local basis. What is needed might be described as a centralized index, and for convenience, supported by an automated information retrieval system so that specific referrals may be made rapidly, effectively and inexpensively.

The heart of any such system is the information it contains. The most difficult part of establishing such a system is locating and cataloging the files whose indexes will be the system.

The Environmental Data Base Directory (EDBD) portion of ENDEX is an automated, documented comprehensive index describing environmental data collections. EDBD enables scientists and managers to answer such questions as: Who has a certain kind of data in a particular area; how was it collected; what form or medium (such as magnetic tape, punched cards, charts, etc.) is it in; and who sponsored the activity? EDS' goal is to have a nationwide environmental inventory of historical data completed by the end of the decade. At present there are just under 2,000 environmental data files described that pertain mostly to the Chesapeake Bay, New York Bight and Great Lakes regions. Efforts currently are underway in Florida, and negotiations have begun to initiate work in North and South Carolina and Georgia.

Handouts have been provided which give more specific information on ENDEX and EDS' EDBDing efforts in Florida.

"EXECUTIVE BRIEFS"

Abstracts of Scientific Papers

An Introduction to the Physical Oceanography and Meteorology of the Gulf of Mexico

William S. Richardson, Nova University

As an introduction to the series of talks on the circulation in the eastern Gulf of Mexico, a brief description of the major features of the physical oceanography of the Caribbean, the Gulf, and the Florida Straits was presented. The relative magnitudes of runoff from the land, evaporation from the Gulf, and flushing of the Gulf by the Yucatan-Loop-Florida current systems were given. A flushing time for the upper waters of the Gulf of 10 to 25 years was suggested. The general meteorology of the eastern Gulf was described, and the variability of the system was stressed.

The Gulf Loop Current

George A. Maul, NOAA/Atlantic Oceanographic and Meteorological Laboratories

The Yucatan Current flows northward into the Gulf of Mexico to a varying extent before turning anticyclonically and exiting through the Straits of Florida. Variability of the northerly penetration has been studied by a 13-month time-series in which the 22°C isotherm at 100 meters depth was used as an indicator of the position of the left hand edge of the current. The data confirm earlier speculation of an annual cycle of spring growth, summer spreading, and autumn-winter decay possibly in phase with the annual cycle of transport of the Florida Current. Interaction of the current with the west Florida Shelf emphasizes the need to monitor or accurately predict the flow if reliable oil-spill trajectories are to be made.

Wind-Induced Currents and Sea Surface Slopes in the Eastern Gulf of Mexico

Wilton B. Sturges and John A. Cragg, Florida State University

Meteorological and tidal records at three Florida Gulf coast stations have been examined for the period 1965-67. Cross-spectral analysis of daily winds and sea levels shows a high coherence at periods of 4 to 20 days. Daily sea levels have been correlated with winds of varying direction and speed with good results. Sea level was found to be most responsive to winds that were within about 10 degrees of the direction of the coast. The magnitude of the sea-level rise caused by longshore winds was 25 cm for a moderate wind of 5 m/sec. Wind components at weather stations separated by up to 300 km were found to have coherences above .6 for the periods of 4 to 100 days. The large horizontal extent of the wind field coupled with the magnitude of the sea-surface slope normal to the coast allows us to infer the presence of broad geostrophic longshore flow. The width of the flow seems to be on the order of 100 to 200 km. Interestingly, onshore-offshore winds induced sea-level fluctuations an order of magnitude smaller than those induced by longshore winds. A longshore slope of 3×10^{-7} for a longshore wind of 5 m/sec is observed; this slope may be caused by a piling up of water against the curving coastline.

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Western Florida Continental Shelf Program

Murice O. Rinkel, State University System of Florida Institute of Oceanography

This paper is an updated revision of a discussion of the Western Florida Continental Shelf Program, November, 1970 - February, 1972, originally prepared by the State University System of Florida Institute of Oceanography (SUSIO) March 21, 1972, on behalf of the University of Miami, National Marine Fisheries Service, Atlantic Oceanographic Meteorological Laboratories, University of West Florida, Florida State University, and University of Florida (text revised January 30, 1974).

Tidal Currents on the West Florida Shelf

Harold Mofjeld, NOAA/Atlantic Oceanographic and Meteorological Laboratories

Tidal currents are responsible for much of the water motion on the West Florida Shelf. What appears to be tidal currents is really a combination of three distinct kinds of motion: Surface tides propagate from the Atlantic Ocean through the Straits of Florida and the Caribbean Sea into the Gulf of Mexico where they form a complicated distribution; these tides produce tidal currents on the West Florida Shelf. At the shelf break, tidal motion on and off the shelf produce undulations in the pycnocline which propagate shoreward across the shelf. These undulations, often called internal tides, produce currents of tidal period which are in opposite directions above and below the pycnocline. During the winter regime on the shelf when the water is vertically homogeneous over much of the shelf, internal tides exist only near the shelf break and seaward. Changes in wind intensity or direction create rotatory currents which on the West Florida Shelf have periods near that of the daily tide. These inertial currents are most significant during intense atmospheric events such as cold fronts and hurricanes. They are therefore also seasonal. There are very few direct observations of currents on the West Florida Shelf; those that exist were made either at the northern or southern limits of the shelf. Any discussion of tidal currents on the West Florida Shelf is necessarily qualitative at the present time.

Response of the West Florida Shelf Circulation to Strong Meteorological Forcing

Christopher N. K. Mooers, University of Miami, Rosenstiel School of Marine and Atmospheric Science

An NSF sponsored, cooperative study (among Florida State University, Nova University, and the University of Miami) of the physical dynamics of continental shelves has been underway since June 1972. To date, three field experiments have been executed on the West Florida Shelf (vicinity of 26°N): (1) a pilot study for a week in June 1972, (2) a five-week experiment in the winter of 1973, and (3) a six-week experiment in the autumn of 1973. A long-term current-monitoring experiment, begun August 1973, is continuing indefinitely. The data are either in the advanced stages of processing or in the early stages of analysis. Approximately 1,000 STD and XBT casts and 2,000 current meter days have already been acquired. From the Winter 1973 experiment, the mean circulation (the order of 10 cm $\sec^{-1}$) tended to parallel the isobaths: northward on the outer shelf, southward on the inner shelf. The variable component of the circulation generally exceeded the mean. It consisted of tidal, inertial, and several-day oscillations. Evidence exists for eddies with dimensions of the order of tens of kilometers. Furthermore, the passage of atmospheric cold fronts clearly induced strong inertial oscillations, coastal upwelling, and a thickening of both the surface and bottom boundary layers. Similar phenomena occurred in the June 1972 Pilot Study with the onset of strong winds associated with Hurricane Agnes. At this stage, it is our impression that the most significant exchange between shelf and offshore waters on the West Florida Shelf occurs during strong meteorological events, e.g., atmospheric cold fronts and hurricane passages. The relative influence of the Loop Current on shelf circulation and exchange has yet to be determined. With present funding, the data acquired to date will be processed, analyzed, synthesized, and reported within two years. With a substantial funding increment, the reporting phase could be achieved within six months.

Seagrasses

Harold J. Humm, Department of Marine Science, University of South Florida

The extensive seagrass beds covering most of the bottom from the intertidal zone out to a depth of six to eight meters from Tarpon Springs to Port St. Joe, Florida Gulf coast, are the most important benthic community in the area. This poorly known but highly productive area should receive a major amount of research attention in connection with the impending offshore drilling and the work should begin immediately.

Benthic Plants in the Eastern Gulf of Mexico

Sylvia A. Earle, Los Angeles County Museum, Los Angeles, California

The biological and geological significance of the submarine meadows of benthic algae and seagrasses in the eastern Gulf of Mexico is reviewed, and the chemical and physical effects of petroleum and drilling operations on the benthic vegetation considered. The status of baseline information about attached plants in the eastern Gulf of Mexico is given, with recommendations on work that should be done in order to evaluate the impact of offshore drilling.

Benthic Invertebrate Communities of the Eastern Gulf of Mexico

William G. Lyons, Florida Department of Natural Resources, and Sneed B. Collard, University of West Florida

Estuarine and offshore benthic invertebrate communities of the eastern Gulf of Mexico are outlined and discussed. On the West Florida Shelf, inshore communities are influenced by terrigenous sand substrates, few limestone outcrops, and overlying coastal waters. Beyond about 30m depths, communities are characteristically tropical, with calcareous sediments and overlying blue, offshore waters. Faunal zone divisions are suggested at depths of approximately 10, 30, 60, 140 and 200m. Much information used in defining these zones, still unpublished, is from HOURGLASS collections. Information on communities of the Mississippi-Alabama Shelf is less complete. The importance of working and publishing previously made collections is stressed.

Potential Effect of Oil Drilling/Production Activities on the Phytoplankton/Zooplankton in the Eastern Gulf of Mexico

Sayed Z. El-Sayed, Texas A & M University; Thomas L. Hopkins, University of South Florida; Karen A. Steidinger, Florida Department of Natural Resources

We are primarily concerned with the potential effect of oil drilling and production activities on the environmental quality in the eastern Gulf of Mexico and the changes in the marine ecosystem brought about by these activities. Our concern for the effects of oil production on phytoplankton/zooplankton is based on the significant roles played by these organisms in marine food chains.

A summary of the research activities carried out in the past few years in the northeastern Gulf of Mexico and off the Western Coast of Florida is given; the review exposed gaps in our knowledge of the biology, general ecology, seasonal and geographic distribution, metabolism and turnover rates of the phytoplankton and zooplankton populations. It also pointed to the need for a study of the effect of the hydrographic conditions on the distribution and abundance of these organisms.

A program for studying ecosystem dynamics of the eastern and northeastern Gulf of Mexico, with special emphasis on the phytoplankton and zooplankton populations in the MAFLA regions, is outlined in this paper.

Biological Indicators of Oceanographic Phenomena

Herbert M. Austin. New York Ocean Science Laboratory

A water mass is a pelagic ecotope, and under specific circumstances can be defined by the species or groups of species of plankton that it supports. Such forms are called biological indicators or bioindicators. They are a dynamic means of following a water mass through space and time and in many cases residual populations can be traced even after the physical characteristics of the mass are no longer detectable with standard techniques. Specific examples in the Gulf of Mexico include the following of the Loop Current velocity core from the baroclinic to barotropic region, entrainment of deeper (100-150m) western Gulf and West Florida Shelf water into the Loop Current, impingement of pelagic waters over the shelf below the thermocline, and the deliniation of regions of upwelling.

Research on Eggs and Larvae of Fishes in the Eastern Gulf of Mexico

Edward D. Houde, University of Miami, Rosenstiel School of Marine and Atmospheric Science

Studies on eggs and larvae of fishes can provide valuable information about the distribution and abundance of the adult populations. Spawning seasons, spawning areas, success of spawning, and even biomass estimates of adult spawning populations can be obtained from egg and larval surveys. Prior to 1971, egg and larvae studies in the Eastern Gulf of Mexico were mostly confined to describing developmental stages. Since 1971, ichthyoplankton surveys associated with cooperative programs such as EGMEX, MARMAP and Sea Grant have provided more detailed information about spawning in this region, and also have accumulated much data on associated physical and chemical factors. Other egg and larval surveys of a more local nature have been carried out by the Florida Department of Natural Resources and National Marine Fisheries Service. Distribution and abundance of eggs and larvae of clupeid fishes have been most studied, but some knowledge of spawning by scombrids, flatfishes, carangids, eels and other fishes has been accumulated. Biomass of the large clupeid resources in the Eastern Gulf is presently being assessed from egg and larvae surveys, and the technique could be expanded to study other species such as snappers, groupers, mullet and mackerel. Routine ichthyoplankton surveys are one means to determine if oil exploration activities significantly change abundance of fishes in the Eastern Gulf.

Nature and Status of the Marine Sport Fishery in the Eastern Gulf of Mexico

Luis R. Rivas, NOAA/National Marine Fisheries Service

The marine sport fishery of the eastern Gulf of Mexico is subdivided into coastal, bottom, offshore, and miscellaneous according to areas fished and fishing methods. The eastern Gulf marine sport fishery is considered as extending from the mouth of the Mississippi River to the Florida Keys. It is estimated that, every year, in this region, 1,480,000 anglers catch 178,277,605 fish weighing 339,832,049 pounds and that the annual sum spent amounts to $263,588,000. Each type of fishery is discussed separately and catch statistics are provided.

Fishery Resources - Commercial

Rolf Juhl, NOAA/NMFS/Southeast Fisheries Center

The subject area extends from the Mississippi Delta to the Dry Tortugas, having a shelf area of 50,000 square miles. The commercial fishery production is taken mostly inside the 50 fathom depth. The U. S. total production in 1972 was 4.7 billion pounds, valued at 700 million dollars. At least 40% of this total (valued at $200 million) was taken in the Gulf. The eastern Gulf produced one third of this total.

The leading commercial species include: shrimp, menhadden, blue crab, muller, snapper and grouper, oyster, industrial bottom fish, and spanish and king mackerel. Underutilized and latent resources include large pelagic fishes (shark, billfish, dolphin and tunas), coastal pelagic (thread herring, sardines and anchovy), and bottom fish (sciaenids - croaker, spot and sea trout).

National Marine Fisheries Service, Southeast Fisheries Center, has conducted at least 180 survey cruises over the last 24 years in the subject area. Over 3,300 stations were occupied in which shrimp and fish trawls, clam dredges, longlines, seines and miscellaneous gear were utilized. An ongoing program is designed to survey the bottom fish resources in the North Central Gulf.

Observations on the Florida Middle Ground Through the Use of Open-Circuit SCUBA

Thomas S. Hopkins, University of West Florida

A series of diving cruises to the Florida Middle Ground, at 28°35'N and 084°16'W, have emphasized studies on the reef-building cnidarian fauna, the echinoderm fauna, and the reef-face microclimate and associated zooplankters. In addition, extensive collections and data on fishes, sponges, molluscs, and algae have resulted.

Dominant cnidarians and echinoderms observed at this study area are described, and reef-zonation is tentatively delimited according to faunal indicators. A recommendation is made that the Florida Middle Ground and the West Flower Garden Bank need to be compared both floristically and faunistically, and as soon as possible.

Comments on the Nature of the Florida Middle Ground Reef Ichthyofauna

Gregory B. Smith, Florida Department of Natural Resources;
Larry H. Ogren, National Marine Fisheries Service

The Florida Middle Ground, an offshore region of irregular submarine topography in the northeastern Gulf of Mexico, harbors a tropical reef ichthyofauna quite unlike (both qualitatively and quantitatively) that of other areas of the West Florida Shelf. The occurrence of numerous fishes representing distributional records (e.g. eastern Gulf, northward range extensions, etc.) emphasizes the ichthyofaunal distinctiveness of the region.

Historically, the Florida Middle Ground has been one of the most productive and consistently fished "reef areas" in the Gulf of Mexico. Presently, most of the bottom fishing for groupers and snappers on the West Florida Shelf is concentrated at the Middle Ground, Elbow and adjacent reef areas.

The structural complexity of the reefs, water column productivity, and varying depths at the Middle Ground are suggested as parameters contributing to the diverse and abundant fish fauna.

Zoogeographically, the Middle Ground reef ichthyofauna is transitional, including warm-temperate, tropical, eurythermic and Gulf of Mexico endemic elements. However, a qualitative comparison of the Middle Ground ichthyofauna with those of other reef areas in the Gulf of Mexico and western Atlantic indicates both greater intra-Gulf homogeneity and Caribbean-West Indian affinity than previously suspected for these populations. The transparent waters, relatively shallow reef crests, steep-profiled topography and carbonate sediments are attractive inducements to many insular (West Indian) reef fishes either rare or absent at other reef sites in the eastern Gulf of Mexico.

Hopefully, information assembled in this paper will emphasize the necessity of obtaining certain baseline data for this unique and little-known segment of the West Florida Shelf which is presently scheduled for exploratory oil-drilling operations. Increased bottom turbidities and sedimentation which may be generated during drilling activities could seriously jeopardize the ecology of the productive reef community at the Middle Ground. The oil-drilling regions in the northwestern Gulf are dominated by warm-temperate, soft bottom faunas which generally exhibit rather broad tolerances to environmental parameters. The tropical reef community at the Florida Middle Ground would be expected to be many times more sensitive to environmental perturbations affiliated with oil exploitation and production.

Inorganic Aspects of OCS Petroleum Operations

Eugene F. Corcoran, Rosenstiel School of Marine and Atmospheric Science, U. M.; Kent A. Fanning, University of South Florida

An overview of water-chemistry studies conducted in the Gulf of Mexico is presented. Phosphorous is best documented in the Gulf, but several important problems, such as phosphorous concentrations in the sediments, are not yet well studied. Exchange rates of nitrogenous nutrients with sediments also needs study, and nitrogenous chemical species need identification. Least is known about the trace metals which, because of complex biochemical and geochemical roles, are perhaps the most important.

Significance of Low Molecular Weight Hydrocarbons in Eastern Gulf Waters

William M. Sackett, Texas A & M University

A several thousand mile survey of dissolved low molecular weight hydrocarbon concentrations in surface water of the Gulf of Mexico indicates that the most important sources of these hydrocarbons are related to man's activities. These sources include ports and estuaries with their associated shipping and tetrochemical activities, offshore drilling, and production platforms and ships which discharge oily ballast water and/or clean their fuel tanks at sea. The water column several miles distant from at least one example from each of the three types of sources showed several orders of magnitude higher concentrations than observed for the open Gulf. Natural seeps are also significant sources of hydrocarbons in the Gulf but the magnitude of their contribution relative to man's is unknown. Low molecular weight hydrocarbon concentrations are proving to be sensitive indicators and should provide an early warning of incipient petroleum pollution in marine environments.

Some Problems Associated With the Collection of Marine Samples and Analysis of Hydrocarbons

John W. Farrington, Woods Hole Oceanographic Institution

The collection of marine samples for the purpose of hydrocarbon analysis must be undertaken with extreme care to avoid contamination during the sampling operation. Similarly, appropriate controls should be carried through the extraction and analysis procedures to insure that hydrocarbons are not introduced into the samples from the ship's atmosphere, the laboratory atmosphere, or from solvents and reagents.

It is essential that intercalibration procedures be carried out so that the results from different laboratories often using different methods can be integrated and compared to provide a basis for understanding the quantitative and qualitative distribution of hydrocarbons in marine samples.

The analysis of marine samples to detect petroleum hydrocarbons in the presence of recently biosynthesized hydrocarbons is discussed. The need for closely spaced sampling stations in some areas to provide baseline data is discussed and illustrated by results of analyses of saturated hydrocarbons in surface sediments from the New York Bight area and the continental shelf to the east.

Experimental Design for an Environmental Program: Hydrocarbon Analysis in an Oil Producing Area

Patrick L. Parker, University of Texas, Marine Science Institute

Petroleum hydrocarbons are present in the water column in areas of off-shore oil production. The chronic level of individual hydrocarbon types was found to be in the 1-10 part per billion level for off-shore Louisiana. In cases where spills occur, the levels may approach the level at which photosynthetic microorganisms and animal eggs are adversely affected (parts per million). It has been demonstrated that present day analytical techniques are adequate to acquire baseline chemical data and that biological experiments can detect adverse effects of aromatic hydrocarbons at environmentally realistic levels.

Structural Framework of the West Florida Continental Shelf

T. E. Pyle, University of South Florida; W. R. Bryant and J. W. Antoine, Texas A & M University

Seismic reflection profiling and sampling of the western margin of the Florida platform and projection of onshore trends show that the Florida Escarpment coincides with the position of a Lower Cretaceous barrier reef north of 27°15'N and south of 24°20'N. The occurrence of Lower Cretaceous evaporites in the south Florida basin suggests that the reef also flourished along the intervening segment of the scarp. This area is now characterized by topographic offsets, canyons and other features which suggest that the reef has been removed by erosion, slumping or faulting. Uplift and subaerial exposure may have been preludes to removal of such large quantities of lithified reef material. These movements may be related to Mesozoic igneous activity indicated by magnetic anomalies and by drilling results in central Florida. Shallow water carbonates recovered at great depths in wells and by means of marine dredging demonstrate subsidence greater than 4.6 km in south-central Florida and greater than 1.8 km along the western marginal escarpment. The structural framework of the Florida platform is little modified by the movement of buried salt. However, some piercement structures (salt domes?) have been found in De Soto Canyon landward of the supposed carbonate platform margin. The Destin Dome may also be related to salt movement, but magnetic data suggest a possible relation between this feature and a deep-seated igneous intrusion. The structural importance of solution activity in the often cavernous limestones of Florida is emphasized by the recent documentation (by seismic methods) of the existence of numerous filled sinkholes on the inner continental shelf.

General and Geotechnical Characteristics of the Surficial Deposits on the West Florida Shelf

H. K. Brooks, University of Florida

The West Florida shelf is a stable carbonate platform over which a thin discontinuous layer of noncohesive sediments occur. The tectonic stability and the geotechnical properties of the sediments and rocks are superior to that of most other offshore areas. No major problems should be expected from solution features; however, each site should be carefully explored to detect and plan for this condition.

The Coastal Sediment Transport System

William F. Tanner, Florida State University

Sediment transport in the coastal zone can be studied in terms of two axes: one, the littoral axis, taken parallel with the coast, is the basis for processes which are fairly well understood; whereas the other, the transverse or "normal" axis, taken at right angles to the coast, provides the orientation for processes which are not well understood. In the real world, the combination of these two sets of processes is very complicated. A delicate balance exists in this complicated system, among available energy, sediment parameters, and resulting geometry, which is easily disturbed and quickly either re-established or converted to a new and different equilibrium. The effects of such disturbances, even though initially small, may be felt over distances measured in kilometers. The effects of the intrusion of any permanent, fixed activities or structures in the area cannot be predicted with assurance, especially with respect to transverse processes.

Accidents, such as an oil spill, may have effects quite different from those referred to above. Here one must consider the implications of oil, even in a very thin film, on beaches, marshes and swamps which -- in Florida -- are developed extensively across a broad spectrum of coastal energy levels. Especially at the lower end of that spectrum, it is not known what the effects will be be, nor is it known how long such effects may persist.

It is also important that efforts be made to identify polluting oils, so that the source can be determined.

SCIENTIFIC PRESENTATIONS

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Physical Oceanography

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An Introduction to the Physical Oceanography and Meteorology of the Gulf of Mexico

William S. Richardson
Oceanographic Center
Nova University
Dania, Florida

Editor's Note: For information pertaining to the presentation see "Executive Brief" or contact:

Dr. William S. Richardson
Oceanographic Center
8000 North Ocean Drive
Dania, Florida 33004

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Wind-Induced Currents and Sea Surface Slopes in the Eastern Gulf of Mexico

Wilton B. Sturges
Department of Oceanography
Florida State University
Tallahassee, Florida

John A. Cragg
Department of Oceanography
Florida State University
Tallahassee, Florida

Editor's Note: For information pertaining to the presentation see "Executive Brief" or contact:

Dr. Wilton B. Sturges
Department of Oceanography
Florida State University
Tallahassee, Florida 32306

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The Gulf Loop Current

George A. Maul
NOAA/Atlantic Oceanographic and Meteorological Laboratories
Miami, Florida

Historical Introduction

Early work in the Gulf of Mexico has been summarized by Galtsoff (1954) who edited a complete overview of the biology, chemistry, geology, and physics of the area. In 1895, Lindenkohl published a map of the temperature field at 250 fathous (457 meters), in degrees farenheit, which is reproduced in figure 1. The warm waters of the Caribbean can be seen flowing northward into the Gulf and penetrating deeply into the ambient thermal field; similarly the Gulf Stream, seen as a region of large horizontal temperature gradient, is flowing easterly and then northerly through the Strait of Florida. In an analysis of these data Sweitzer, in 1898, reported that the circulation was a spreading of this inflow which resulted in an anticyclonic circulation around the entire Gulf basin. Parr, in 1935, reported the opposite conclusion using ATLANTIS data taken in 1933: the Gulf Stream takes only the shortest path from Yucatan to the Strait of Florida. Even after reviewing Dietrich's 1939 map of the salinity maximum core, which reflects the deep penetration seen in figure I, Leipper expressed this divergence of opinion as the state of knowledge in 1954. Work done in the 1960's, notably by Leipper, Cochrane, Nowlin, and others at Texas A & M University, led Leipper (1970) to speculate that there was an annual cycle in the current patterns in the eastern Gulf. A time-series to establish the seasonality was reported during the survey's progress by Maul (1973). This paper is a preliminary descriptive report on the time history of the current from August 1972 to September 1973.

Observation Program

The sequence of pathlines of the Gulf Loop Current was started to obtain the location of the cyclonic edge by ship in order to evaluate several methods of location by satellite. Figure 2 is a cross-stream transect taken on May 1, 1973, from north to south along the suborbital track of the Earth Resources Technology Satellite (ERTS). Speed of the vessel was about 10 knots, so the horizontal distance traveled from 1200 to 1700 GMT is approximately 90 kilometers.

Cross-section plots of surface salinity (hourly), chlorophyll-a (continuous), volume scattering function, B_{45} (hourly), radiometric surface temperature (dashed; continuous), and bucket temperature (solid; hourly) are drawn above the cross-section of temperature down to 450

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meters. Figure 2 is oriented such that the current flow is into the plane of the page and on the right-hand side (i.e., facing downstream). Surface observations are typical in that there is an increase of temperature and salinity, and a decrease of chlorophyll-a and scattering when entering the current from the cyclonic (left-hand edge facing downstream) side. The temperature field dominates the salinity to produce less dense water to the right in agreement with a geostrophically balanced flow; chlorophyll-a and scattering interact to cause a color shift from greenish-blue outside the current, to the cobalt blue so characteristic of this relatively sterile water mass.

Using the historical precedent of Leipper (1970) and others, the 22°C isotherm at 100 meters depth was chosen as an indicator of the current. This isotherm is approximately 20 kilometers to the right of the cyclonic edge, and near the surface velocity maximum. The observational strategy greatly improved tracking efficiency as it gave the research vessel an average boost of 2 knots. The actual tracking was done using expendable bathythermographs (XBTs). After observing hydrographic sections across the Florida Straits from Cosgrove Shoal to Havana, and across the Yucatan Straits from Cabo San Antonio to Isla Contoy, a zig-zag tracking pattern was initiated. Typically, hourly BT's were taken. When the depth of the 22°C isotherm exceeded 125 meters or so, the ship's course was altered 90° to the left. This course was run until the 22°C isotherm was less than 80 meters or so, and then course was altered to the right. The pattern was continued from Yucatan, around the Loop to Dry Tortugas, in all but a few cases, where weather or fuel considerations made it advisable to run for Key West. After each trip, the position data were replotted and a smooth plot constructed, which made a best fit to the estimated courses and speeds made good. Positioning was accomplished using Loran A, radar, visual, and celestial observations. It is difficult to estimate errors, but based on Loran A- radar comparisons, ± 1-3 kilometers seems reasonable.

The expendable BT data were adjusted so that the average surface reading on the strip chart recorder was in agreement with the average bucket temperature. The strip chart recorder was tested (and adjusted if necessary) before and after each cruise with a test canister. Infrared temperatures were calibrated using a blackbody source in the laboratory so that the radiometric temperatures could be compared to the bulk values. This latter comparison is necessary in order to study the infrared observations of the NOAA-2 scanning radiometer, and to properly interpret those data.

Discussion

Pathlines of the 22°C isotherm at 100 meters depth are summarized in figure 3. The series was obtained at 36-day intervals, coincidental with the 18-day period of ERTS. Dates of each survey are labeled on the appropriate pathline; where the cruise started at Yucatan in one month and ended off Dry Tortugas in another, both months are labeled. The shortest tracking time was three days and the longest six days, so that near synopticity was accomplished. Hydrographic station transects of the straits added two days to each cruise. Conditions prior to the first cruise were that a large anticyclonic detached eddy was observed in May, 1972. The current flowed essentially north from the Yucatan Straits and curved in a gentle anticyclonic curvature, ending tangent to the Florida Keys platform.

By September conditions had changed markedly. The initial current direction had a significant easterly component and flowed directly toward the west Florida shelf. There was evidence of Loop Current water on the shelf, and the 22°C isotherm apparently went aground well north of Dry Tortugas. It is notable that a red tide of *Gymnodinium breve* was reported on the Florida shelf at this time. By late October the current had reformed to its southernmost extent, and evidence of Florida Bay water flowing south through the Keys was noted in both the ship track and an ERTS image. Murphy, *et al*. (1974) have used this evidence to partially document the source of the first reported Florida east coast red tide. Apparently the organisms were carried by the current through the Florida Straits and exchanged with local coastal water north of Miami.

By December 1972, the current had swung to the west and had penetrated into the Gulf to the same latitude as August. At 24°N, the stream flowed in a sharp anticyclonic turn to the east. January 1973 was the only month in which transects of the Straits were not obtained. This was due to 50-knot winds and high seas forcing the ship to turn back. Only four crossings were obtained but sufficient detail permitted the observation, for the first time, that the current penetrated north of Dry Tortugas (25°N).

The "spring intrusion" (Leipper, 1970) continued through February, March, April-May, and June when the current extended to 27°N. As the current penetrated deeper it also swung further to the west and seemed to be controlled by the bottom topography of Campeche Bank in agreement with a potential vorticity conserving flow as postulated by Molinari and Cochrane (1972). North of 24°N the isobaths curve sharply to the west and the current flows into deeper water where different dynamics probably dominate.

A deep intrusion in July 1973, coupled with a marked cyclonic curvature off the west Florida shelf, led us to expect separation of an eddy by the following cruise. The deep intrusion from the east was not a sampling artifact; a second vessel from the State University System of Florida Institute of Oceanography (SUSIO) obtained hydrographic station data across the shelf and out into the main current throughout this area. The furthest western extent of the current also occurred in July.

By August 1973, the current system extended almost to the Mississippi Delta. The expected eddy had not separated. Very low salinity water (<24°/oo) was recorded by the SUSIO vessel, again cooperating with the NOAA ship, all along the current-edge off the Florida Shelf. The hydrographic section in the Florida Straits had surface salinities less than 30°/oo along the cyclonic boundary. Since the Loop Current was so close to the delta area, and there are no other significant sources of fresh water, it seems probable that this was Mississippi River water in origin.

During the last cruise, September 1973, the current was found well to the south again, at approximately the same penetration as February. A trackline from Ft. Myers, west to 87°W, and north to Pascagoula, confirmed that an anticyclonic eddy had indeed separated and a significant change in the hydrography of the eastern Gulf had occurred in one month. There was no hint in the extensive August data that a recirculation had begun as a prelude to the eddy formation, although observations by Cochrane (personal communication, 1974) made between the April-May and June cruises, showed substantial closure in his isotherm field in this area.

Niiler and Richardson (1973) obtained a one-year time series of the transport of the Florida Current between Miami and Bimini. These data, taken during 1964-1970, show a transport minimum in December and a maximum in June. The data in figure 3 show a minimum penetration into the Gulf in October-November and a maximum in July-August, which is in fair agreement with the average transport cycle.

Significance to Shelf Acitvities

The discussion on the red tide of 1972 points out the significance of the Loop Current's interaction with the shelf waters. In fact, even the area of the Mississippi Delta must be considered part of the ecosystem in question.

The OLD SALT fishing tournament is another case in point of the Loop Current's effect on man's activities. This cooperative venture between scientists and sportsmen is designed to study the best location for game fish. The cyclonic side of currents such as the Gulf Stream are regions of upwelling; this upwelled water, being rich in nutrients, forms the basis for a food chain which comprises a favorite feeding ground for large predatory fish. The June 1973 tournament was quite successful because of the close proximity of the cyclonic edge to the shelf. The July 1973 event however was one of the poorest in fish catch statistics and was probably due to the significant offshore shift of the current. This same experience has been noted in at least two other commercial fisheries around the eastern Gulf.

Richardson (1974, personal communication) suggested the following plausible scenario: consider the case of an oil spill in July at the shelf break off St. Petersburg. The east and southeast prevailing winds will advect the surface waters out toward the Loop Current area at perhaps 10 mi./day. If, as in this series, the current is there, the oil could be transported into the Florida Straits at 75 mi./day perhaps to be blown ashore at Miami Beach. If the current had broken into an eddy at this time (e.g., Cochrane, 1972), the oil could be trapped in the anticyclonic gyre, prevailing winds permitting. If a third possibility occurs (no Loop Current at this latitude), the oil may be driven ashore on the northern or western shore of the Gulf. Similar arguments can be fostered for the winter condition when the wind direction has a strong northerly component and remnant eddies may exist. It is clearly necessary to know the location of the current, or to be able to accurately predict its location, if we are to have a meaningful model for oil spill advection forecasting.

Further Monitoring Needs

One of the purposes of the time-series given in figure 3 was to obtain surface observations for correlation with ERTS and the NOAA-2 meteorological satellite. In a recent publication Maul and Gordon (1974) discuss the relationship between the upwelling spectral irradiance, and identification of the cyclonic boundary. This work is being extended to the general problem of water mass identification by optical properties. It is necessary to extend the work, in order to catalog the characteristic spectral reflectance with the biological, chemical, and geological (suspended sediments) variables in these waters. Such a task must be started prior to the inception of oil drilling so that a baseline is established. Further, remote sensing of ocean color will never be quantified, unless this catalog is initiated.

Infrared sensing of sea surface temperature in the subtropics, for the purpose of locating oceanic boundaries, is virtually useless during most of the summer and early autumn. This is because, in the Gulf of Mexico for example, the sea surface becomes isothermal, and the strong horizontal thermal gradient at the surface front (figure 2) of the current disappears. The data given in figure 3 are being analyzed using the techniques of Maul and Sidran (1973) for current boundary location during the winter months. The reliability of this method is expected to be superior to that using ERTS, because the ERTS sensors are not optimized for ocean color radiance levels or spectral distribution. Future spacecraft will overcome some of these shortcomings, but not all of them.

This points out the need to model the Gulf Basin numerically as has been proposed by AOML (unpublished document, 1973). That proposal calls for the use of these and other data in a prognostic mode in order to develop adequate circulation predictions, which in turn, are needed to model oil spills. Additionally, the interaction with the west Florida shelf must be known, since this will be the offshore boundary condition for models of the shelf circulation. Such studies will lead to the combination of observations (surface vessel, remote platform, and buoy) needed to specify the currents at any given time and hence be responsive to any catastrophic event.

Conclusion

Preliminary analysis of the data presented in this paper shows that the Gulf Loop Current has an annual cycle but the variations from year to year are as yet unknown and unpredictable. The current strongly influences the shelf circulation and interacts to exchange waters and hence particles and organisms. Knowledge of the location of the cyclonic boundary is necessary for oil spill trajectory models; a proper combination of surface vessel, remote vehicle and buoy observations to input into prognostic numerical models is as yet unknown.

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List of Figures

1. Lindenkohl's 1895 map of the temperature field (°F) at 250 fathoms in the Gulf of Mexico. Data are from soundings made by Sigsbee, Bartlett, and Brownson between 1874 and 1883. The shallow waters (<250 fms) of Campeche Bank and the west Florida shelf, strippled on the chart, outline the topographic constraints of the Gulf Loop Current. The deep intrusion of warm Caribbean water was not recognized as a current pattern at all, even as late as 1954.

2. Thermal cross-section of the Gulf Loop Current on 1 May 1973 northwest of Dry Tortugas. Horizontal distance for the five-hour run is 90 kilometers. Bucket temperature (hourly) is solid line and radiometric (10.5 - 12.5 μm) temperature is dashed, other variables connect to their respective ordinate. The indicator isotherm is 22° C at 100 meters which is approximately 20 kilometers to the right of the maximum surface thermal gradient facing downstream.

3. Pathlines of the 22° C isotherm at 100 meters from August 1972, through September 1973. Surveys were 36 days apart and in coincidence with every other transit of the Earth Resources Technology Satellite: where two months are given, the survey extended over the change of date. Cruises were from three to six days in duration and the research ship motored with a following current.

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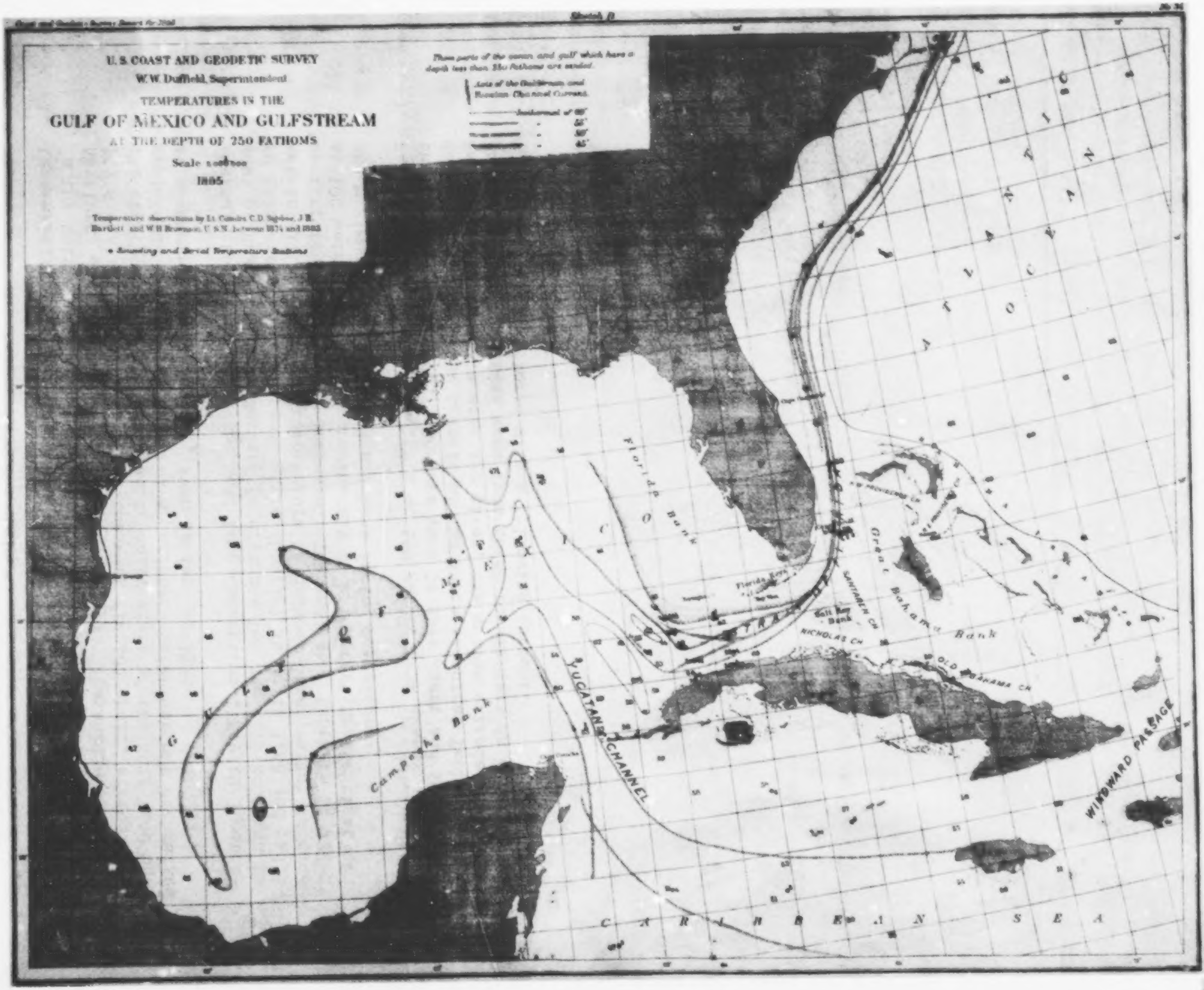
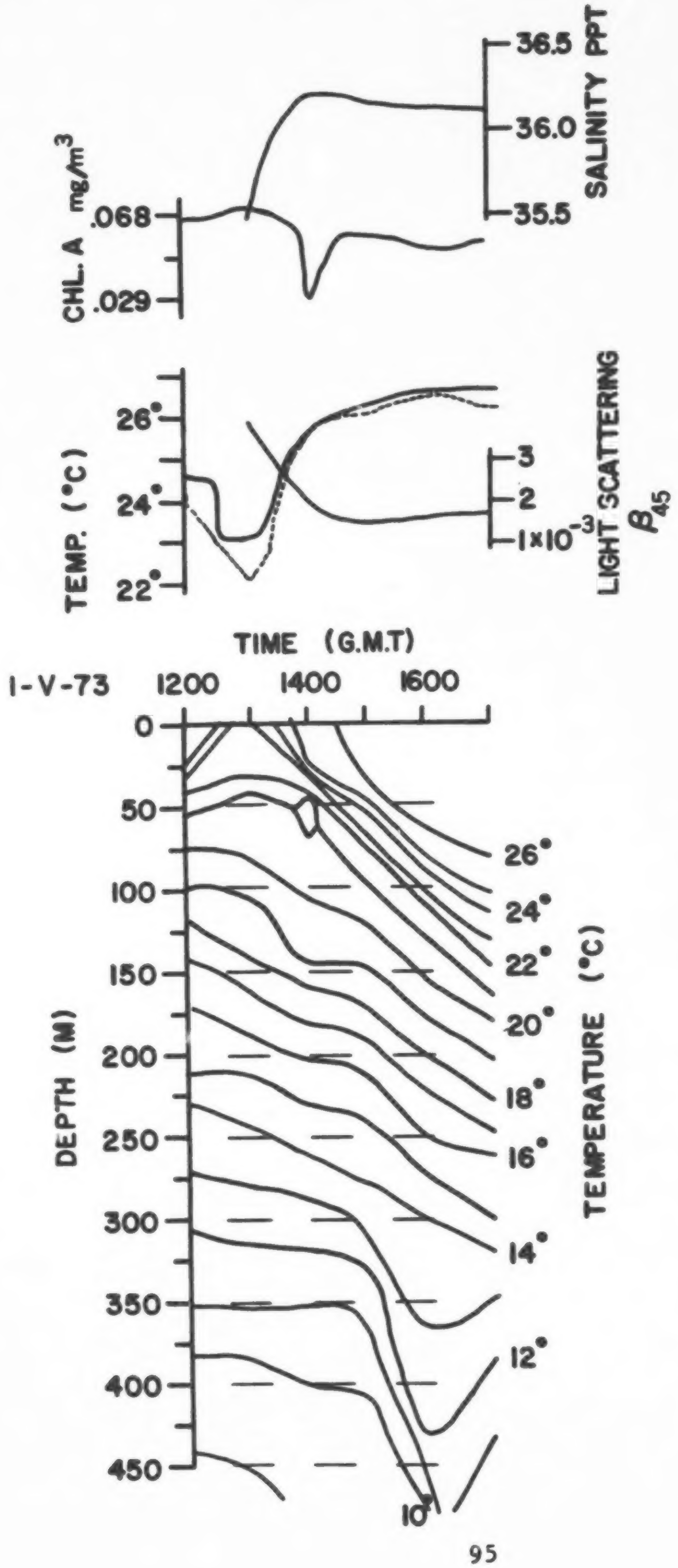
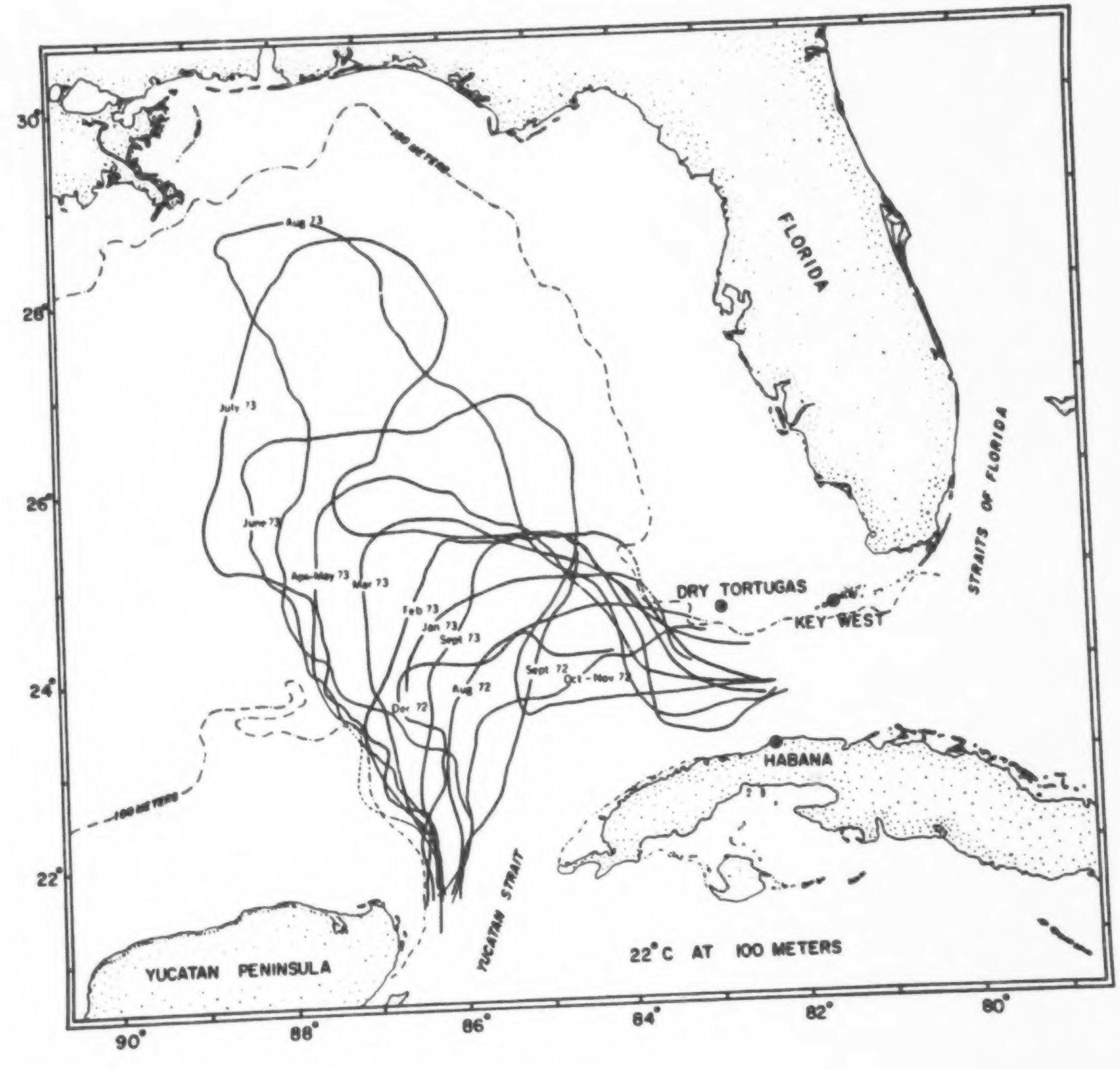

Sketch
U.S. COAST AND GEODETIC SURVEY
W. W. Duffield, Superintendent
TEMPERATURES IN THE
GULF OF MEXICO AND GULFSTREAM
AT THE DEPTH OF 250 FATHOMS
Scale
1885
Temperature observations by Lt. Comdrs. C. D. Sigsbee, J. R. Bartlett and W. H. Brownson, U.S.N. between 1874 and 1885
• Sounding and Serial Temperature Stations
Those parts of the ocean and gulf which have a depth less than 250 fathoms are sanded.
Axis of the Gulfstream and Yucatan Channel Current.
Isothermal of 60°
55°
50°
45°
GULF OF MEXICO
Campeche Bank
Florida Bank
YUCATAN CHANNEL
STRAITS
Florida Keys
Salt Key Bank
NICHOLAS CH
SANTAREN CH
Great Bahama Bank
OLD BAHAMA CH
WINDWARD PASSAGE
ATLANTIC OCEAN
CARIBBEAN SEA

①


CHL. A mg/m^3
.068
.029
36.5
36.0
35.5
SALINITY PPT
TEMP. (°C)
26°
24°
22°
3
2
1×10^{-3}
LIGHT SCATTERING β_{45}
TIME (G.M.T)
1-V-73
1200
1400
1600
DEPTH (M)
0
50
100
150
200
250
300
350
400
450
26°
24°
22°
20°
18°
16°
14°
12°
10°
TEMPERATURE (°C)

②


FLORIDA
STRAITS OF FLORIDA
DRY TORTUGAS
KEY WEST
HABANA
YUCATAN STRAIT
YUCATAN PENINSULA
22°C AT 100 METERS
100 METERS
100 METERS
Aug 73
July 73
June 73
Apr-May 73
Mar 73
Feb 73
Jan 73
Sept 73
Sept 72
Oct - Nov 72
Aug 72
Dec 72
30°
28°
26°
24°
22°
90°
88°
86°
84°
82°
80°

③

Western Florida Continental Shelf Program

Murice O. Rinkel
State University System of Florida
Institute of Oceanography
St. Petersburg, Florida

(A discussion of the Western Florida Continental Shelf Program, November, 1970 - February, 1972, which was prepared by the State University System of Florida Institute of Oceanography, March 21, 1972, on behalf of the University of Miami, National Marine Fisheries Service, Atlantic Oceanographic Meteorological Laboratories, University of West Florida, Florida State University, and University of Florida. Revised January 30, 1974.)

Introduction

In the 1970 University of Miami proposal to the National Sea Grant Program, Dr. Martin A. Roessler submitted a project "to study the natural fluctuations in the yet relatively unexploited stock of commercial fish for annual and seasonal variations in the abundance of spawning products, i.e. eggs and larvae, on the Western Florida Continental Shelf. Samples would be collected by a controlled rate of lowering and retrieval, double oblique 505 μ mesh plankton tows to within five meters of the bottom or to a maximum depth of 200 meters with environmental support information in the form of temperature and salinity." (Dr. Houde letter 2/17/71).

Both Dr. Roessler and the Sea Grant personnel realized that if important and useful information were to be obtained by a project of this nature, it would be necessary to utilize all of the fish larvae and egg oceanographic resources within the State of Florida. Dr. Roessler, therefore, contacted the Southeast Fisheries Center (SFC) of the National Marine Fisheries Service (NMFS) of the National Oceanic and Atmospheric Administration (NOAA) in Miami and requested their cooperation and participation in the project. NMFS agreed, and a working group was formed between the University of Miami (Dr. Edward Houde*) and NMFS (Dr. Albert Jones, Dr. William Richards, and Dr. Frank Hebard) (Dr. Houde letter 2/17/71).

The SFC/NMFS participants of this working group were also members of a cooperative interdisciplinary study of the Loop Current structure in the Eastern Gulf of Mexico called EGMEX. The working group for EGMEX consisted of the University of Miami, Texas A&M University, Atlantic Oceanographic and Meteorological Laboratories (AOML), the Southeast Fisheries Center, Nova University, University of West Florida, Florida State University, University of South Florida, and the State University System of Florida Institute of Oceanography (SUSIO), with SUSIO acting as the coordinating agency for EGMEX (Rinkel, 1971).

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*Dr. Houde replaced Dr. Roessler as University of Miami Principal Investigator.

SFC/NMFS realized that the physical, chemical and biological data, and, more important, the personnel and scientific contributions resulting from the EGMEX study, would be beneficial to any scientific study on the Western Florida Continental Shelf. Dr. Hebard, therefore, discussed the project during the planning meeting for EGMEX III to determine whether EGMEX was interested in participating in the study. EGMEX agreed to schedule the R/V JOIE DE VIVRE Cruise SUS-7030 on the shelf, during EGMEX III, to determine the operational and research problems that might occur if EGMEX cruises were combined with the Western Florida Continental Shelf Program. Further, SUSIO agreed to discuss the project with personnel in the seven state universities (EGMEX III Planning Session Minutes).

A meeting was held on February 3, 1971, in which the University of Miami, SFC/NMFS, University of West Florida, Florida State University, University of Florida, and University of South Florida agreed to a Western Florida Continental Shelf Program, with SUSIO acting as the coordinating agency. (Western Florida Continental Shelf Program Meeting, Tallahassee, 2/3/71). It was agreed that the following scientific objectives would be studied:

A. To determine the seasonal distribution and abundance of eggs and larvae of commercial fishes (University of Miami, NOAA/NMFS/SFC).

B. A seasonal synoptic survey of the physical oceanographic parameters (NOAA/NMFS/SFC, SUSIO, and University of Miami).

C. To determine the distribution and concentration of IPO_4, SiO_3, NO_2, NO_3 and relate them to the water mass characteristics of the Loop Current and Caribbean waters (NOAA/NMFS)*.

D. To collect physical data to conduct model verification on numerical and experimental models of circulation on the continental shelf in the northeastern Gulf of Mexico (Florida State University).

E. To determine the areal geology and substratum types of the slope and inner continental shelf of peninsular Florida (University of Florida).

*The Atlantic Oceanographic Meteorological Laboratories, at a later date, agreed to participate in the study to determine the distribution and concentration of IPO_4, SiO_3, NO_2 and NO_3 and relate them to AOML studies of the water mass characteristics of the Loop Current and Caribbean waters study (Mr. George Berberian letter 2/3/71).

F. To take bottom pictures and sediment samples on the continental shelf (University of Florida).

G. To determine the engineering properties of the sediments (University of Florida).

H. To collect demersal fishes and macroinvertebrates for studies of their seasonal and areal distributions and abundance (Florida State University).

I. To relate planktonic biological indicators collected with open-closing nets to the density structure of the Gulf of Mexico Loop Current (Florida State University).

J. To establish the presence or absence of Idotea metallica (Crustacea: Isopoda) in the EGMEX area, correlate the resulting information with an ongoing worldwide zoogeographical determination of this species (University of West Florida).

K. To collect pelagic fish eggs and larvae to determine seasonal distribution, density, and speciation of sport and commercial finfish that spawn or occur in the coastal waters adjacent to Tampa Bay (St. Petersburg Beach Biological Laboratory - NOAA/NMFS).

L. To collect and bring back to the laboratory living material to rear some fish species through metamorphosis to help make positive identification of eggs and larvae (St. Petersburg Beach Biological Laboratory - NOAA/NMFS).

A Standard Master Grid Station Pattern, based on 15-mile centers from the ten fathom line across the shelf, was established. (Appendix I). These stations were to be occupied in May, August, and November of 1971 and February, 1972 (Chart I).

SUSIO then communicated the contents and the agreements of the Western Florida Continental Shelf Program to the NMFS St. Petersburg Biological Laboratory (NOAA/NMFS). This laboratory was under contract to the National Park Service to conduct a seasonal study in the Everglades National Park area between Cape Romano and Cape Sable out to five miles offshore. The locations of the stations on the project called "South Florida Environmental Studies Program" are shown in Chart II.* They agreed to combine these data with the Shelf study.

In June of 1971, Mr. Bruce Johnson of the State of Florida Coastal Coordinating Council requested the assistance of SUSIO in locating people within the state who would be interested in taking baseline data within the Perdido and Escambia Bays and out to nine miles offshore (the territorial limits of the waters in the State of Florida) for use by his agency in determining the economic, social, and environmental use of the

Bongo tows were not taken at the stations shown in Charts II and III.

resources within this area. A group consisting of SUSIO, the University of Miami, the Environmental Protection Agency, AOML, Gulf Universities Research Corporation (GURC), the State of Florida Department of Pollution Control, and TRW, Inc., joined together to run a cruise in September of 1971, consisting of physical, chemical, geological, trace element, and pesticide data. The location of stations is shown on Chart III.

An environmental measurement program, common and beneficial to the scientific requirements of all of the projects, was to be taken at these master station locations. This consisted of:

A. STD and/or oceanographic station casts (1.7 liter Niskin bottles equipped with reversing thermometers).

B. BT and/or XBT lowerings.

C. Surface temperature.

D. Drift bottle releases.

E. As much surface weather data as each vessel was equipped to measure.

In support of the commercial fish larvae and egg project, the proposed MARMAP Bongo data collection system was to be towed at each station using 50 meters per minute lowering rate and a retrieval rate of 15 meters per minute. These data were to be transmitted to the MARMAP project leaders as a preliminary examination of the biomass resources on the Continental Shelf and to help determine the future MARMAP sampling locations.

In support of individual research projects, the following collections were to be made:

A. Neuston net tows from one hour before sunset to one hour after daybreak.

B. At certain selected sections of the grid pattern a standard ICITA plankton net would be towed at the surface.

C. During the period of the study a single core and/or grab sample would be taken at each station location with an accompanying bottom picture.*

The shiptime was scheduled on vessels from the University of Miami (R/V GERDA) and SUSIO (R/V TURSIOPS, R/V DAN BRAMAN, and R/V BELLOWS) with an understanding that when the R/V OREGON II was available, she would be utilized to conduct sampling out and across the Loop Current and as a back-up vessel for operations on the shelf in case of bad weather. When an EGMEX program occurred during any of the sampling months, the cruises would carry an EGMEX expedition number.

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*NMFS Contract N-042-70-71 (N) Provision of Plankton Sorting Services.

The following agreements were reached as to the responsibility of the participants in the collection, reduction, and analysis of the resulting data:

A. The state universities and the University of Miami would supply the major portion of the shiptime and personnel for shipboard collection. The other participants would supply vessels and personnel as their existing commitments would allow.

B. NOAA/NMFS/SFC would be responsible for the reduction of all temperature and salinity data to corrected values except for the salinity samples collected during R/V GERDA cruises which were to be analyzed by the University of Miami. The construction of station curves for temperature and salinity and quality control would be performed by SUSIO. Digitization of mechanical BT's would be performed by SUSIO and jointly by NOAA/NMFS/SFC and SUSIO for expendable BT's. The preparation of these corrected data for submission to NODC would be the joint responsibility of NOAA/NMFS/SFC and SUSIO.

C. AOML would be responsible for the data reduction of the IPO_4, SiO_3, NO_2, and NO_3, and the analysis of them as related to the density structure. These data would be combined with the temperature and salinity data by SUSIO and submitted to NODC.

D. The rough sorting of the plankton samples would be provided by NOAA/NMFS/SFC, University of Miami, University of West Florida, Florida State University, and Florida Atlantic University. The rough sorting by the state universities would be under contract to NMFS.* After the rough sorting of fish eggs and larvae, the remainder of the plankton samples would be made available by NOAA/NMFS/SFC to other participants or scientific personnel who had the ability and necessary resources to conduct other identifications and would write analytic reports. Sport fishing and commercial larvae and eggs would then be identified by personnel from the University of Miami and NOAA/NMFS/SFC.

E. Samples from the upper two small nets of the Bongo net array would be made available for biological indicator studies to Florida State University whenever the Western Florida Continental Shelf Program was conducted in conjunction with an EGMEX program.

F. The Bongo net arrays during May would have two nets and for August, November, 1971, and February, 1972, four nets. Since only one of these nets would be subject to rough sorting and fish egg and larvae identification by the University of Miami and NOAA/NMFS/SFC, the remaining samples would be available to other participants or scientific

*Grab sample and bottom pictures were not taken at stations indicated on Chart II.

personnel who had the ability and necessary resources to conduct other identifications and write analytic reports. At the completion of the program these samples would be stored and maintained by SUSIO for distribution to interested parties subject to the review and approval of the participants in the Western Florida Continental Shelf Program.

G. Neuston net tows would be analyzed by the University of West Florida.

H. Geological samples and bottom photography would be reduced and analyzed by the University of Florida.

I. Drift bottle releases and the resulting data analyses would be the responsibility of NOAA/NMFS/SFC.

J. NMFS St. Petersburg Beach Biological Laboratory (NOAA/NMFS) would be responsible for the data reduction and analysis of the resulting samples taken by standard ICITA plankton nets towed at the surface on selected sections of the standard grid pattern.

Cruises

A total of 25 cruises have been completed during the pre-EGMEX sampling and during operations in May, June, August, and November of 1971 and February of 1972 utilizing the R/V BELLOWS (8), R/V DAN BRAMAN (4), R/V ISLAND WATERS (1), R/V JOIE DE VIVRE (1), R/V OREGON II (2), R/V GERDA (4), and R/V TURSIOPS (5). Of these 25 cruises, 17 of them were part of the EGMEX series, i.e. EGMEX III (3), EGMEX IV (6), EGMEX V (5), and EGMEX VI (3).

Track Charts

A composite track chart of all of the stations occupied by the vessels during each operational month is recorded in Charts IV through IX. The location of each station has been plotted as a small circle the diameter of which is equal to two miles (the assumed navigational accuracy) available from SUSIO in plotting charts to the scale of US CG & S 1007 for all stations occupied during the study. This chart site is the standard plotting chart for the EGMEX data and therefore allows intercomparison of the shelf with the EGMEX data. There is one exception to this and that is Chart III for ESCAROSA I. A total of 919 stations have been occupied.

Methods and Instructions

A major problem faced in the utilization of data taken by individual research projects or routine baseline data collections has been the lack of adequate documentation of collection methods and instructions. This prevents the future data user from adequately utilizing the data because of lack of data verification. Since the desire of the project was to create a seasonal baseline data bank, standard instruction and collection methods were established for the common core environmental data of temperature, salinity, inorganic phosphate, nitrate, nitrite, and silicate and plankton tows using either ICITA nets, open and closing nets or NOAA/NMFS Bongo net arrays. To insure that the Western Florida Continental Shelf Program data were compatible with the EGMEX program, the collection methods were standardized to that sampling program.

During the collection period the following collection systems were used:

STD lowerings were made using a Bissett-Berman Model 9060.

XBT's were T-4's.

Mechanical BT's were either 200 or 450 ft. units.

Drift bottle releases were TABL Miller beer type and consisted of either 12 or 24 bottles per release.

Hydrographic casts consisted of either 1.7 or 5-liter Niskin bottles equipped with two protected reversing thermometers and below 150 meters, an unprotected thermometer.

Plankton tows were by two or four-net NMFS Bongo net arrays, one meter ICITA nets, and one-half meter opening-closing nets. The Bongo net and many of the ICITA net tows taken at the master station locations of the Western Florida Continental Shelf Program were double oblique hauls. The ICITA net tows taken during the South Florida Environmental Studies Program (Chart II) were either surface tows in water less than three meters or oblique tows in water greater than three meters.

Trawls were by 16 ft. tri-nets.

Cores were two feet, two inches diameter.

Grabs were either Petersen or Ekman.

Dredges were Ekman.

Bottom photography was 35 mm. color.

While not attached as part of this report, data collections were taken according to standard instruction sheets, which were:

1. EGMEX '70 III INSTRUCTIONS FOR SAMPLING FOR MODEL NO. 9060 BISSETT-BERMAN STD UNIT.
2. SHIPBOARD DIRECTIONS FOR COLLECTING SEA WATER SAMPLES.
3. INSTRUCTIONS FOR SAMPLING FOR IPO_4, SiO_3, NO_2, and NO_3.
4. INSTRUCTIONS FOR SAMPLING PARTICLE DATA COLLECTION.

5. INSTRUCTIONS FOR SAMPLING FOR TRACE METALS.

6. INSTRUCTIONS FOR COLLECTION AND PROCESSING OF CHLOR $\bar{a}$ EGMEX V.

7. EGMEX II - ISCAROSA I.

8. PLANKTON SAMPLING INSTRUCTIONS - SHELF ICHTHYOPLANKTON SURVEY SAMPLING.

9. INSTRUCTIONS FOR SAMPLING FOR PELAGTIC FISH EGGS AND LARVAE BY 1 METER 505 μ MESH NETS.

10. INSTRUCTIONS FOR SAMPLING OPENING-CLOSING ½ METER CM^2 FLOWMETER EQUIPPED WITH 200 μ MESH PLANKTON NET TO COLLECT SHELLED MIXED ZOOPLANKTON AS BIOLOGICAL INDICATORS OF WATER MASSES AND CURRENTS.

Copies of these may be obtained from SUSIO; similarly, cruise reports.

The individual research projects attached to the program used the following data collection methods:

The collection of pelagic fish eggs and larvae to determine seasonal distributions, density, and speciation of sport and commercial finfish that spawned or occurred in the coastal waters adjacent to Tampa Bay were surface 30-minute ICITA net tows.

Neuston net tows were 30-minute surface tows taken during nighttime hours.

Summary of Observations

In Table I are listed the vessels, the cruise numbers, and a summary of all observations taken during the 25 cruises. While a total of 919 stations were occupied, not all stations had each of these observations. There are master plots of locations of observations for physical-chemical (STD, Surface Temperature, BT, XBT, Drift Bottle, Hydro, and Optical); for biological (Bongo, Opening-Closing, ICITA, Neuston, and Trawls); and for geological (Cores, Grabs, and Camera) to the plotting scale of the US C & GS 1007 chart. Copies of these may be obtained from SUSIO.

State of the Reduction of Data

As of December 31, 1973, the data for temperature and salinity collected by STD lowerings, ocean station casts, XBT's, and MBT's have be been analyzed, corrected, quality controlled, and submitted to NODC for the 21 cruises completed between May 7, 1971, and February 12, 1972. (Table II).

Vessel	Operational Organization or Agency	NODC Ship Identification
R/V BELLOWS	SUSIO	8B
R/V DAN BRAMAN	SUSIO	8C
R/V GERDA	University of Miami	GE
R/V OREGON II	NOAA/NMFS	60
R/V TURSIOPS	Florida State University	TI

The data from the EGMEX III operations of R/V ISLAND WATERS Cruise IW-7007, R/V JOIE DE VIVRE Cruise J-7014, and R/V TURSIOPS Cruise have not been processed as part of the Western Florida Continental Shelf Program. They have been considered as part of the pre-planning operation for this study and as such are being submitted within the EGMEX envelope.

Rough sorting of the plankton taken during these 21 cruises has been completed and the fish eggs and larvae submitted to the University of Miami and NOAA/NMFS/SFC. The identification of these particular samples has been completed by Drs. Edward D. Houde and William J. Richards (Houde, 1973) (Houde and Fore, 1973). Under the agreement entered into by these two participants, the plankton samples from all Bongo net arrays have been transferred to the custody of SUSIO for distribution to interested parties. A number of partial reports have been completed, and the work of the University of Miami will be reported in the Marine Environmental Implication of Offshore Drilling in the Eastern Gulf of Mexico conference proceedings. The South Florida Environmental Studies Program has been completed with analysis of the data collected and submitted to the Everglades National Park system as a report (Lindall, 1972).

The ESCAROSA collections have had complete analysis for temperature, salinity, oxygen, inorganic phosphate, nitrate, nitrite, silicate, trace metal, pesticides, sediment size particles, and clay minerals. The preliminary results of the trace metals, pesticides, sediments, and clay fractions have been issued in three separate reports (Corcoran, 1972) (Griffin, 1972) (Jones, 1972). These reports may be obtained from the Florida Coastal Coordinating Council.

These three separate reports along with supplementary information supplied by non-funded agencies, universities, and organizations that participated in EGMEX IV and the Western Florida Continental Shelf Program have been combined into one comprehensive document. This document is presently published and entitled "An Oceanographic Survey of the Florida Territorial Sea of Escambia and Santa Rosa Counties". To date, none of the reports from the individual research projects in connection with the Western Florida Continental Shelf Program have been released. However, the report on pelagic fish eggs and larvae to determine seasonal distribution, density, and speciation of finfish that spawn and occur in coastal waters adjacent to Tampa Bay is in press. Details concerning this study may be obtained by writing to the Gulf Coastal Fisheries Center.

Data Location

To assist possible users of the data in locating the parameters collected during this study, which might be common to the South Florida Environmental Studies, the ESCAROSA I, and the Western Florida Continental Shelf Programs the depository locations are listed below:

Temperature, salinity, oxygen, inorganic phosphate, nitrate, nitrite, silicate - Environmental Data Service/NODC.

Plankton net collections, which have been analyzed and reduced to numbers or identifications, are as follows:

A. Fish eggs and larvae from Bongo nets - University of Miami and NOAA/NMFS/SFC.

B. ICITA net tows of South Florida Environmental Studies Program - Gulf Coastal Fisheries Center.

C. ICITA net tows for fish eggs and larvae to determine the seasonal distribution, density, and speciation of finfish that spawn and occur in coastal waters adjacent to Tampa Bay - Gulf Coastal Fisheries Center.

D. Yet unsorted or identified plankton samples - SUSIO.

E. Trace metals, pesticides, and geological data from ESCAROSA I - Florida Coastal Coordinating Council.

Products

It was the intent of the participants to produce a number of environmental atlases using the combined data from within the program. The first of these atlases will be a physical atlas of temperature, salinity, and sigma t.

This atlas will consist of vertical sections for temperature, salinity, and sigma t plotted along either longitude or latitude. The contour intervals for the various parameters will be temperature, $1^{\circ}C$; salinity, $0.02\ ^{\circ}/oo$; and sigma t, 0.02.

These contour intervals are in agreement with the EGMEX program and will allow inter-comparison of the data from the programs. The depth scale is one inch to 50 meters.

The location of these vertical sections is shown on Chart I along with the computer identification numbers assigned to each vertical section. If data were available from two or more stations on any of these computer sections, the vertical distribution has been constructed and will appear in the atlas.

Horizontal charts have been constructed for temperature, salinity, and sigma t at the surface, standard depths of 10, 20, 30, 40, 50, 75, and 100 meters, and at the bottom with the following exceptions:

1. June does not have a standard depth of 100 meters

2. February does not have a standard depth of 100 meters.

Contour intervals of these charts are similar for each of the parameters to those in the vertical sections. In the construction of the bottom charts, the observations must have been taken within five meters of the bottom to be included in the charts. The master station positions as indicated in Appendix I in the Western Florida Continental Shelf Program appear as circles. Data taken within the operational area but at locations other than these master stations are indicated by appropriate symbols and identified by ship numbers. Both the vertical sections and the horizontal charts have been drawn to the scale of CGS 1007 and as such are comparable to EGMEX data. On the vertical sections the location of oceanographic station bottles has been indicated by a solid circle. On these sections the type of collection method used follows the station number, and the following symbols have been used:

O = Ocean Station Cast.

X = XBT.

S = STD Lowering Model 9060.

The data from the Ocean Station Casts have been reduced, digitized, and placed onto punch cards in the NODC format as follows:

1. The BT or XBT taken directly before the cast was entered onto the station curve using the surface reversing thermometer temperature as a set-up temperature.

2. The profile of this in situ measurement was used in constructing the temperature curve of the Oceanographic Station Cast.

3. Since the XBT or MBT taken before the cast was lowered to the bottom, temperature data may extend below the bottom bottle of the Oceanographic Station Cast.

4. The salinity curve was drawn, taking into account the inflection points of the temperature field.

5. The station curves were then compared by the Montgomery method against stations along the plotting latitude or longitude and to the nearest station north and south or east and west of the plotting section.

On the STD lowerings all casts had at least a calibration bottle at the surface and bottom. These bottles contained two protected reversing thermometers and on the bottle above the STD unit, an unprotected reversing thermometer. The calibration results were plotted, and the lowerings have been corrected to align best fit with a range of ± .02°C in temperature or ± .03 °/oo in salinity. This calibration has been submitted with the data to NODC.

The oceanographic cast data, the STD lowerings, the XBT's, and MBT's were digitized to include temperature at half and whole degrees and any inflection point in which the linear relationship of the temperature profile changes by more than ± 0.02°C. Salinity values were determined for these temperature values, and the salinity was read at every 0.2 °/oo along with its corresponding temperature. Sigma t was digitized at every 0.2 sigma t unit. The data, therefore, have been digitized to within the accuracy of the data collection systems, and curves can be constructed from them using straight line relationships allowing any user to use a ruler and graph paper to construct a curve to determine any value not presently digitized.

For the Oceanographic Station Casts the original observed data from the bottles have been submitted to EDS/NODC and entered into their ocean station files. These data are computer printed out in NODC format for inclusion in the atlas. XBT and STD lowerings have been digitized as described above and computer printed out in the NODC format for inclusion in the atlas.

The digitization standards as described above have been entered into NODC format and on punch cards, and these punch cards are available at cost from SUSIO. These cards were used in a NODC computer program to plot working horizontal charts and vertical sections by EDS/NODC and form the working vertical sections and horizontal charts from which the final camera ready figures were drawn.

The data list-outs will be presented in the atlas in this form to allow each individual a choice either to use the figure or to have the corrected raw data for his own interpretation. Copies of all XBT data may be obtained from SUSIO. MBT lowerings were digitized as described above and may be obtained from SUSIO.

There are a total of 104 vertical sections and 123 horizontal charts.

Month	Vertical Sections	Horizontal Charts
May	24	24
June	5	21
August	43	27
November	22	27
February	10	24

These sections and charts may be obtained from SUSIO for the cost of reproducing Xerox copies. The atlas text, figures, and observed data are in camera ready form for publication, but at the present time no funds are available for printing an atlas. The work in preparing this material has been supported by funds from:

National Science Foundation - Contract No. GA-29590

American Petroleum Institute

Florida Petroleum Council

Florida Coastal Coordinating Council

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TABLE I

Vessel & Cruise No.	Sta.	Days	STD	Sfc. T.	BT	XBT	D.B.	Hydro	Optical	Bongo	O/C	ICITA	Neus.	Trawl	Core	Grab	Dredge	Camera
October, 1970																		
R/V ISLAND WATERS IW-7007	63	11	24	63	0	31	0	0	0	0	0	0	0	0	0	0	0	0
R/V JOIE DE VIVRE J-7014	59	12	0	59	55	0	0	0	0	0	0	0	0	0	0	0	0	0
R/V TURSIOPS T-7070	26	12	0	22	0	13	0	20	8	0	8	0	0	4	0	0	4	0
May, 1971																		
R/V BELLOWS B-7102	40	10	0	40	0	0	0	40	0	0	0	40	0	18	40	0	0	0
R/V DAN BRAMAN DB-7103	86	12	0	86	73	0	0	86	0	86	0	15	0	0	1	72	0	61
R/V TURSIOPS T-7114	39	9	0	39	10	0	0	39	0	0	0	37	18	1	0	0	1	0
R/V GERDA G-7113	NO DATA AVAILABLE - VESSEL FAILURE																	
June, 1971																		
R/V GERDA G-7117	31	9	0	31	31	0	0	31	0	31	0	0	0	0	0	0	0	0
August, 1971																		
R/V BELLOWS B-7103	40	6	0	40	0	0	0	40	40	0	0	40	0	25	0	0	0	0
R/V DAN BRAMAN DB-7109	100	17	7	100	93	0	(100) 1200	100	0	99	0	46	0	0	0	0	0	0
R/V TURSIOPS	81	18	0	81	63	20	(81) 972	81	0	51	0	4	29	0	0	0	0	0

Vessel & Cruise No.	Sta.	Days	STD	SFC. T.	BT	XBT	D.B.	Hydro	Optical	Bongo	O/C	ICITA	Neus.	Trawl	Core	Grab	Dredge	Camera
August, 1971																		
R/V BELLOWS B-7109	11	14	6	2	0	14	2 (24)	2	6	1	6	0	0	0	0	0	0	0
R/V DAN BRAMAN DB-7110	8	5	0	8	8	0	0	0	0	8	0	0	4	0	0	0	0	0
R/V OREGON II O-7129	10	8	0	10	0	9	10 (120)	2	0	5	1	0	5	0	0	0	0	0
September, 1971																		
R/V DAN BRAMAN DB-7113	30	3	0	30	31	0	204	30	0	0	0	0	0	0	0	0	0	0
R/V TURSIOPS T-7123	40	6	26	40	40	0	0	40	0	0	0	0	0	0	0	0	6	0
R/V BELLOWS B-7105	30	3	0	30	29	0	264	29	0	0	0	0	0	0	0	0	16	0
November, 1971																		
R/V GERDA G-7127	2	5	0	2	2	0	0	2	0	2	0	0	0	0	0	0	0	0
R/V TURSIOPS T-7129	33	7	0	33	37	0	0	33	33	33	0	0	0	0	33	68	0	0
R/V BELLOWS B-7017	45	11	0	45	39	5	0	45	0	31	0	42	20	0	0	0	0	0
R/V BELLOWS B-7108	40	7	0	40	0	0	0	40	40	0	0	40	0	24	0	0	0	0
R/V OREGON II O-7131	28	15	0	28	0	27	0	3	0	22	0	22	5	0	0	0	0	0

Vessel & Cruise No.	Sta.	Days	STD	SFC. T.	BT	XBT	D.B.	Hydro	Optical	Bongo	O/C	ICITA	Neus.	Trawl	Core	Grab	Dredge	Camera
February, 1972																		
R/V BELLOWS B-7201	22	10	0	22	17	3	0	19	0	17	0	15	12	0	0	0	0	0
R/V BELLOWS B-7202	40	7	0	40	0	0	0	40	40	0	0	40	0	24	0	0	0	0
R/V GERDA G-7202	15	9	0	15	15	0	0	15	0	15	0	0	5	0	0	0	0	0
TOTAL	919	226	63	906	543	122	2784	737	167	401	016	361	98	96	74	140	127	61

TABLE II

Cruise Numbers			NODC Column	NODC		Ship	
SUSIO	Vessel	SFESP	28-30	Ref. No.	Cruise Dates	Days	Stations
SUS-7113	DB-7103	None	113	31-2003	May 7-18, 1971	13	86
SUS-7114	T-7114	None	114	31-8298	May 7-15, 1971	9	39
SUS-7107	B-7102	001	001	31-7033	May 15-23, 1971	8	40
None	G-7117	None	117	31-1774	June 26-July 4, 1971	9	31
SUS-7119	B-7103	002	002	None	Aug. 1-6, 1971	6	40
SUS-7120	DB-7109	None	120	31-2004	Aug. 9-23, 1971	15	100
SUS-7121	T-7121	None	121	31-2005	Aug. 7-25, 1971	19	81
SUS-7122	B-7104	None	122	None	Aug. 20-Sept. 2, 1971	14	19
SUS-7123	O-7129	None	129	31-1896	Aug. 9-29, 1971	21	10
SUS-7124	DB-7110	None	124	None	Aug. 25-29, 1971	5	8
SUS-7125	DB-7113	None	125	31-1852	Sept. 14-16, 1971	3	30
SUS-7126	T-7123	None	126	31-1851	Sept. 14-16, 1971	3	40
SUS-7127	B-7105	None	127	31-1850	Sept. 14-16, 1971	3	30
SUS-7133	B-7108	003	003	None	Oct. 30-Nov. 5, 1971	6	40
SUS-7132	B-7107	None	132	31-2100	Nov. 6-16, 1971	11	45
SUS-7134	G-7127	None	127	None	Nov. 7-14, 1971	8	2
SUS-7131	T-7129	None	131	31-2099	Nov. 9-15, 1971	7	33
SUS-7135	O-7131	None	131		Nov. 2-16, 1971	7	24
SUS-7201	B-7201	None	201	31-1907	Feb. 2-11, 1972	10	22
None	G-7202	None	202		Feb. 1-8, 1972	8	15
SUS-7202	B-7202	004	004	31-7033	Feb. 12-18, 1972	7	40

PERMANENT STATION LOCATIONS AND NUMBERS FOR THE WESTERN FLORIDA CONTINENTAL SHELF PROGRAM

STATION NO.	DEPTH (Fathoms)	LAT. N.	LONG. W.
1	38	24°30'	83°13'
2	600	24 30	83 47
3	1850	24 30	84 20
4	13	24 45	82 14
5	15	24 45	82 30
6	17	24 45	82 47
7	28	24 45	83 03
8	29	24 45	83 31
9	70	24 45	83 54
10	11	25 00	82 04
11	15	25 00	82 21
12	20	25 00	82 37
13	26	25 00	82 54
14	33	25 00	83 11
15	37	25 00	83 27
16	70	25 00	84 01
17	1600	25 00	84 34
18	8	25 15	81 37
19	8	25 15	81 53
20	11	25 15	82 10
21	18	25 15	82 27
22	23	25 15	82 44
23	29	25 15	83 01
24	34	25 15	83 17
25	40	25°15'	83°34'
26	8	25 30	81 43
27	9	25 30	82 00
28	15	25 30	82 16
29	18	25 30	82 34
30	25	25 30	82 50
31	32	25 30	83 07
32	36	25 30	83 24
33	43	25 30	83 40
34	88	25 30	84 14
35	1800	25 30	84 48
36	6	25 45	81 50
37	12	25 45	82 07
38	15	25 45	82 24
39	19	25 45	82 41
40	26	25 45	82 57
41	32	25 45	83 14
42	39	25 45	83 30
43	60	25 45	83 47
44	10	26 00	82 14
45	16	26 00	82 30
46	20	26 00	82 47
47	25	26 00	83 04
48	33	26 00	83 21

PERMANENT STATION LOCATIONS
WESTERN FLORIDA CONTINENTAL SHELF PROGRAM
Page 2

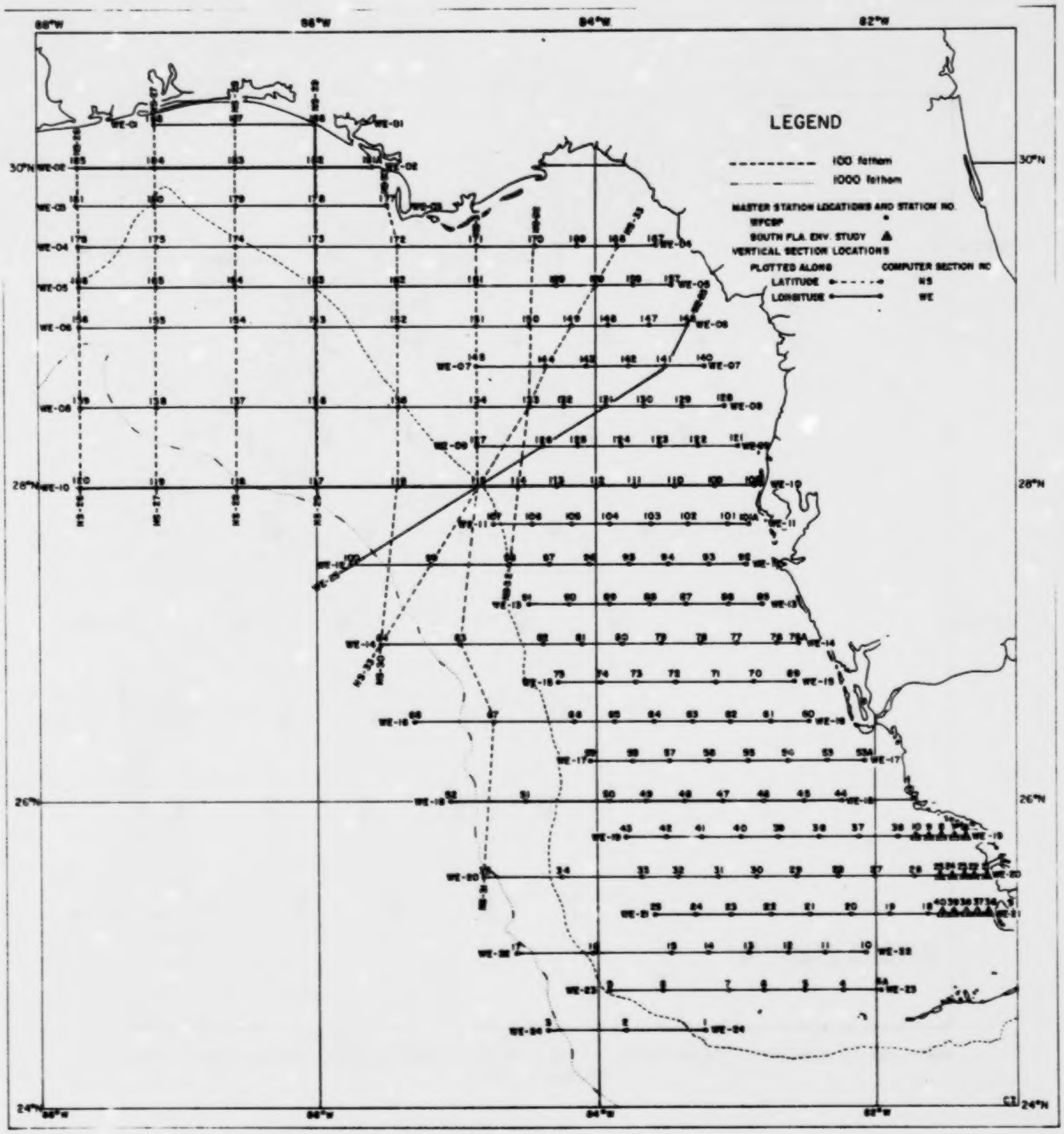
STATION NO.	DEPTH (Fathoms)	LAT. N.	LONG. W.
49	39	26°00'	83°38'
50	65	26 00	83 54
51	120	26 00	84 29
52	1820	26 00	85 02
53	8	26 15	82 20
54	15	26 15	82 37
55	19	26 15	82 54
56	28	26 15	83 11
57	33	26 15	83 28
58	42	26 15	83 44
59	77	26 15	84 02
60	10	26 30	82 27
61	14	26 30	82 44
62	21	26 30	83 01
63	27	26 30	83 18
64	35	26 30	83 34
65	50	26 30	83 51
66	80	26 30	84 08
67	180	26 30	84 43
68	1800	26 30	85 17
69	11	26 45	82 34
70	17	26 45	82 51
71	22	26 45	83 07
72	29	26 45	83 25
73	35	26°45'	83°42'
74	48	26 45	83 58
75	80	26 45	84 15
76	11	27 00	82 41
77	17	27 00	82 58
78	22	27 00	83 14
79	29	27 00	83 31
80	35	27 00	83 48
81	51	27 00	84 05
82	85	27 00	84 22
83	350	27 00	84 57
84	1790	27 00	85 31
85	8	27 15	82 48
86	10	27 15	83 04
87	23	27 15	83 21
88	28	27 15	83 37
89	35	27 15	83 54
90	50	27 15	84 12
91	80	27 15	84 29
92	8	27 31	82 56
93	16	27 31	83 12
94	22	27 31	83 29
95	26	27 31	83 46
96	35	27 31	84 03

PERMANENT STATION LOCATIONS
WESTERN FLORIDA CONTINENTAL SHELF PROGRAM
Page 3

STATION NO.	DEPTH (Fathoms)	LAT. N.	LONG. W.	STATION NO.	DEPTH (Fathoms)	LAT. N.	LONG. W.
97	50	27°31'	84°20'	121	6	28°15'	82°59'
98	90	27 31	84 37	122	11	28 15	83 16
99	370	27 30	85 11	123	15	28 15	83 33
100	1780	27 30	85 45	124	19	28 15	83 49
101	8	27 46	83 03	125	19	28 15	84 08
102	16	27 46	83 20	126	29	28 15	84 23
103	20	27 46	83 37	127	50	28 15	84 51
104	26	27 46	83 54	128	5	28 30	83 05
105	25	27 46	84 10	129	11	28 30	83 23
106	55	27 46	84 27	130	14	28 30	83 39
107	110	27 46	84 44	131	18	28 30	83 56
108	5	28 00	82 52	132	17	28 30	84 14
109	10	28 00	83 09	133	27	28 30	84 29
110	15	28 00	83 26	134	32	28 30	84 51
111	20	28 00	83 43	135	103	28 30	85 25
112	25	28 00	83 59	136	190	28 30	86 00
113	32	28 00	84 17	137	323	28 30	86 34
114	42	28 00	84 34	138	550	28 30	87 09
115	100	28 00	84 51	139	1350	28 30	87 43
116	280	28 00	85 25	140	5	28 45	83 13
117	650	28 00	86 00	141	11	28 45	83 30
118	1600	28 00	86 34	142	13	28 45	83 46
119	1550	28 00	87 09	143	18	28 45	84 04
120	1475	28 00	87 43	144	19	28 45	84 21

PERMANENT STATION LOCATIONS
WESTERN FLORIDA CONTINENTAL SHELF PROGRAM
Page 4

STATION NO.	DEPTH (Fathoms)	LAT. N.	LONG. W.
145	28	28°45'	84°51'
146	6	29 00	83 20
147	9	29 00	83 37
148	13	29 00	83 54
149	15	29 00	84 10
150	17	29 00	84 28
151	21	29 00	84 51
152	39	29 00	85 25
153	140	29 00	86 00
154	220	29 00	86 34
155	477	29 00	87 09
156	900	29 00	87 43
157	5	29 15	83 27
158	9	29 15	83 44
159	12	29 15	84 01
160	14	29 15	84 17
161	15	29 15	84 51
162	23	29 15	85 25
163	95	29 15	86 00
164	205	29 15	86 34
165	420	29 15	87 09
166	223	29 15	87 43
167	5	29 30	83 34
168	9	29 30	83 51
169	12	29°30'	84°08'
170	13	29 30	84 24
171	9	29 30	84 51
172	9	29 30	85 25
173	33	29 30	86 00
174	120	29 30	86 34
175	210	29 30	87 09
176	33	29 30	87 43
177	10	29 45	85 29
178	23	29 45	86 00
179	75	29 45	86 34
180	120	29 45	87 09
181	19	29 45	87 43
182	17	30 00	86 00
183	38	30 00	86 34
184	21	30 00	87 09
185	14	30 00	87 43
OPTIONAL STATIONS			
181A	10	30 00	85 36
186	10	30 15	86 00
187	12	30 15	86 34
188	13	30 15	87 09
189	520	24 00	83 02
190	600	24 00	83 34
191	1600	24 00	84 06


88°W
86°W
84°W
82°W
30°N
28°N
26°N
24°N
LEGEND
100 fathom
1000 fathom
MASTER STATION LOCATIONS AND STATION NO.
WFCSP
SOUTH FLA. ENV. STUDY
VERTICAL SECTION LOCATIONS
PLOTTED ALONG
COMPUTER SECTION NO
LATITUDE
NS
LONGITUDE
WE
WE-01
WE-02
WE-03
WE-04
WE-05
WE-06
WE-07
WE-08
WE-09
WE-10
WE-11
WE-12
WE-13
WE-14
WE-15
WE-16
WE-17
WE-18
WE-19
WE-20
WE-21
WE-22
WE-23
WE-24

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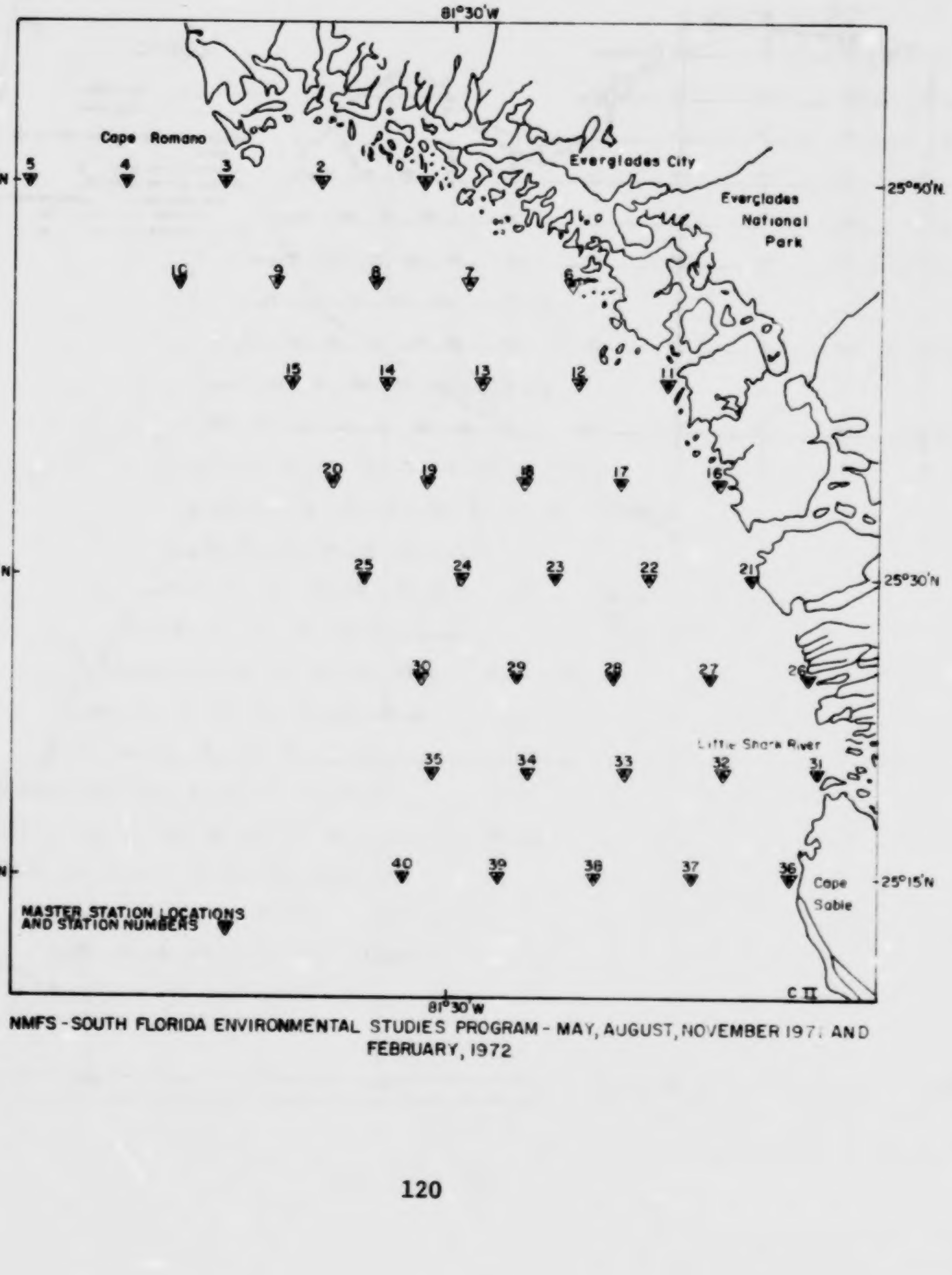
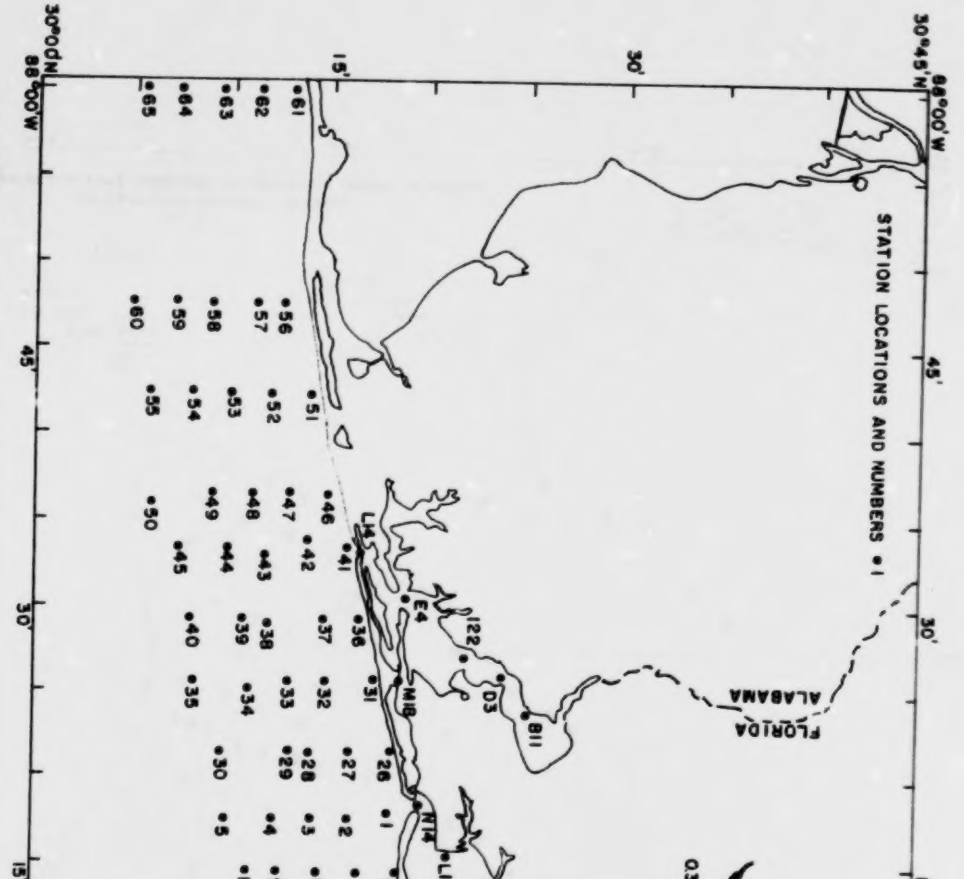
C II

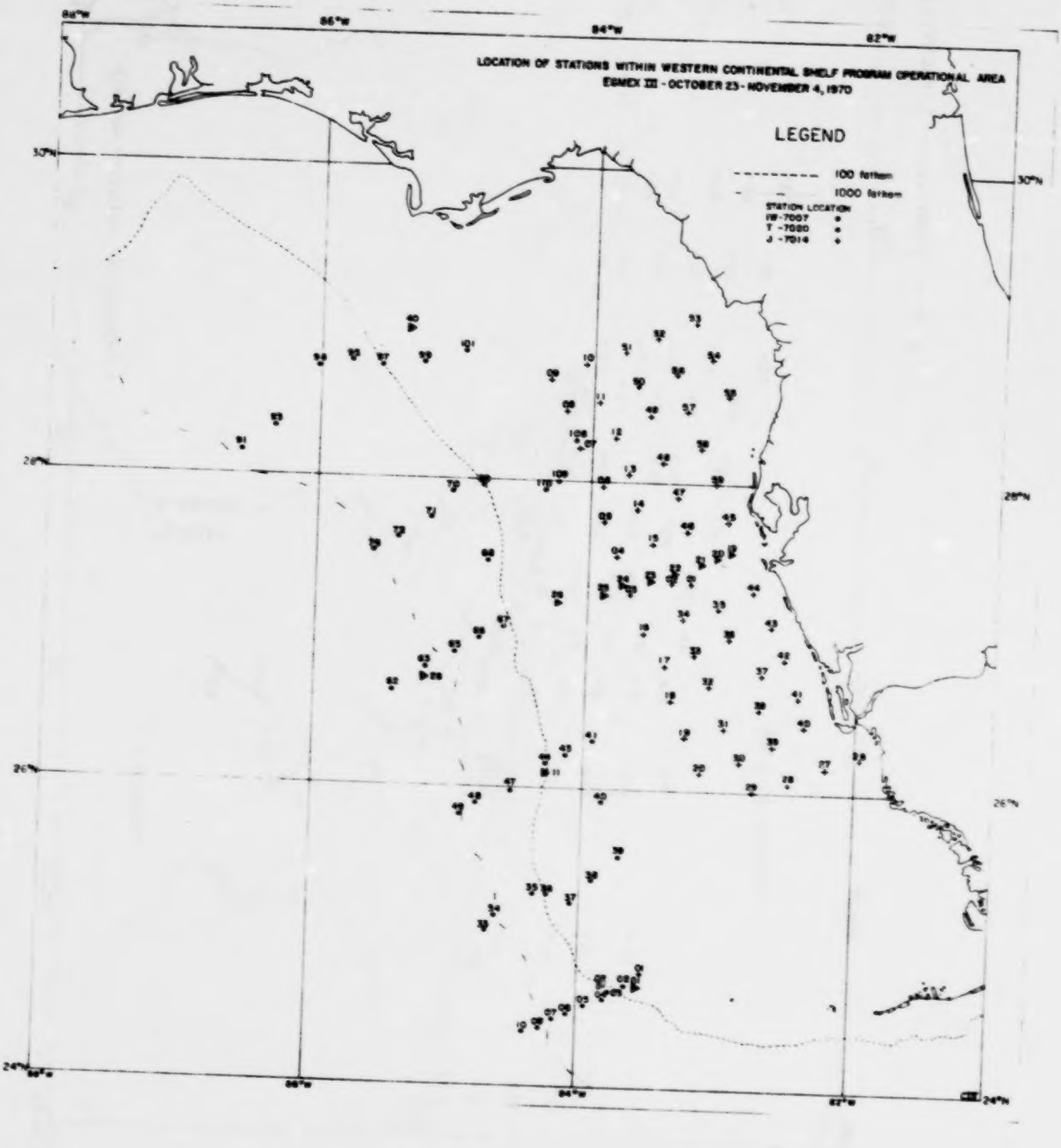

81°30'W
Cape Romano
Everglades City
Everglades National Park
25°50'N
5
4
3
2
25°50'N
10
9
8
7
6
15
14
13
12
11
20
19
18
17
16
25°30'N
25
24
23
22
21
25°30'N
30
29
28
27
26
Little Shark River
35
34
33
32
31
25°15'N
40
39
38
37
36
Cape Sable
25°15'N
MASTER STATION LOCATIONS AND STATION NUMBERS
81°30'W
C II

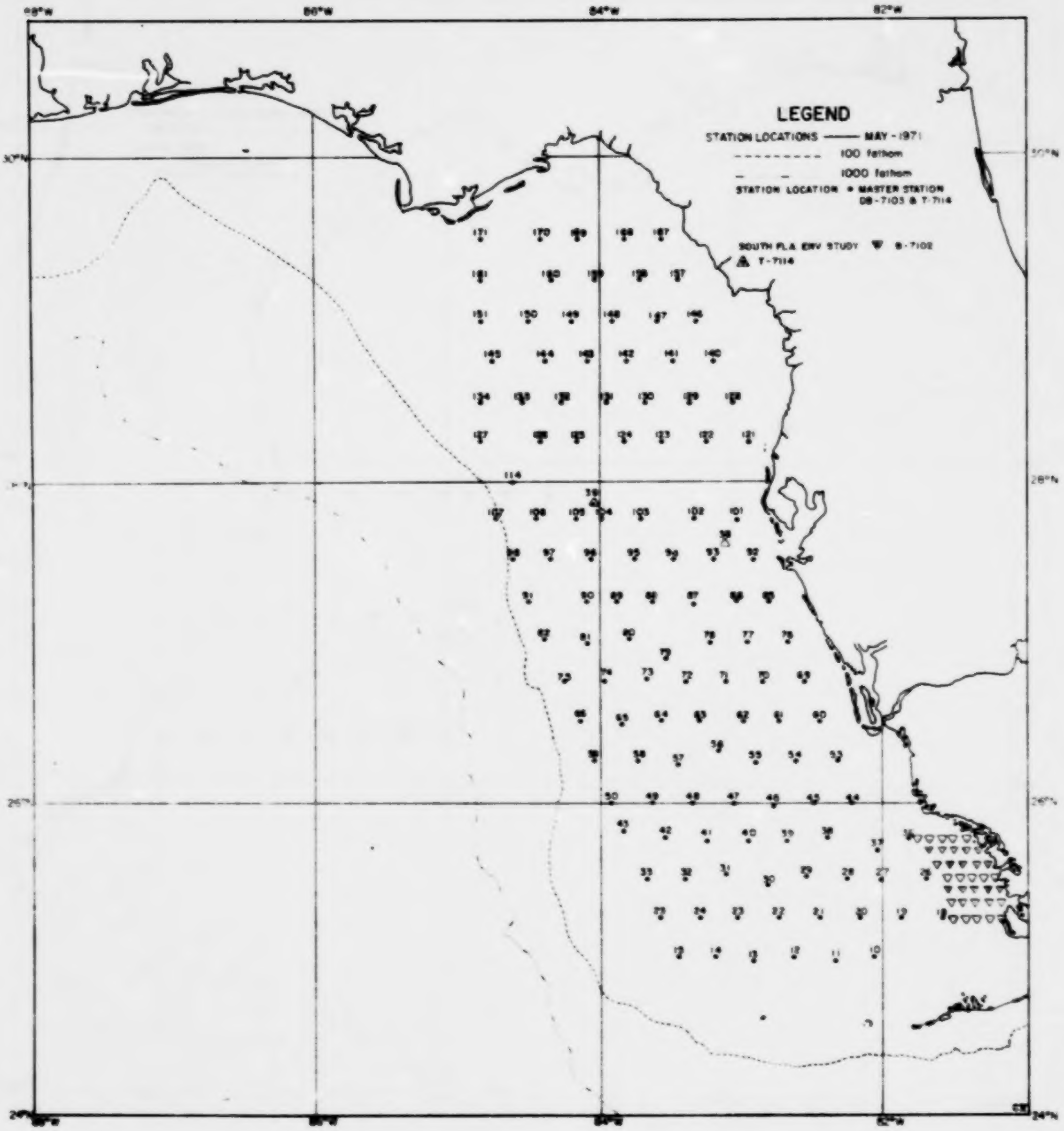
NMFS - SOUTH FLORIDA ENVIRONMENTAL STUDIES PROGRAM - MAY, AUGUST, NOVEMBER 1971 AND FEBRUARY, 1972


STATION LOCATIONS AND NUMBERS •1
ESCAROSA
ALABAMA
FLORIDA
GULF OF MEXICO
88°00'W
30°45'N
45'
30'
15'
87°00'
86°45'W
30°00'N
CIII
B11
D3
I22
E4
L14
M18
N14
L19
J18
J8
G53
D45
F14
D2
F3
C9
O.37
O.9
•1 •2 •3 •4 •5 •6 •7 •8 •9 •10 •11 •12 •13 •14 •15 •16 •17 •18 •19 •20 •21 •22 •23 •24 •25 •26 •27 •28 •29 •30 •31 •32 •33 •34 •35 •36 •37 •38 •39 •40 •41 •42 •43 •44 •45 •46 •47 •48 •49 •50 •51 •52 •53 •54 •55 •56 •57 •58 •59 •60 •61 •62 •63 •64 •65

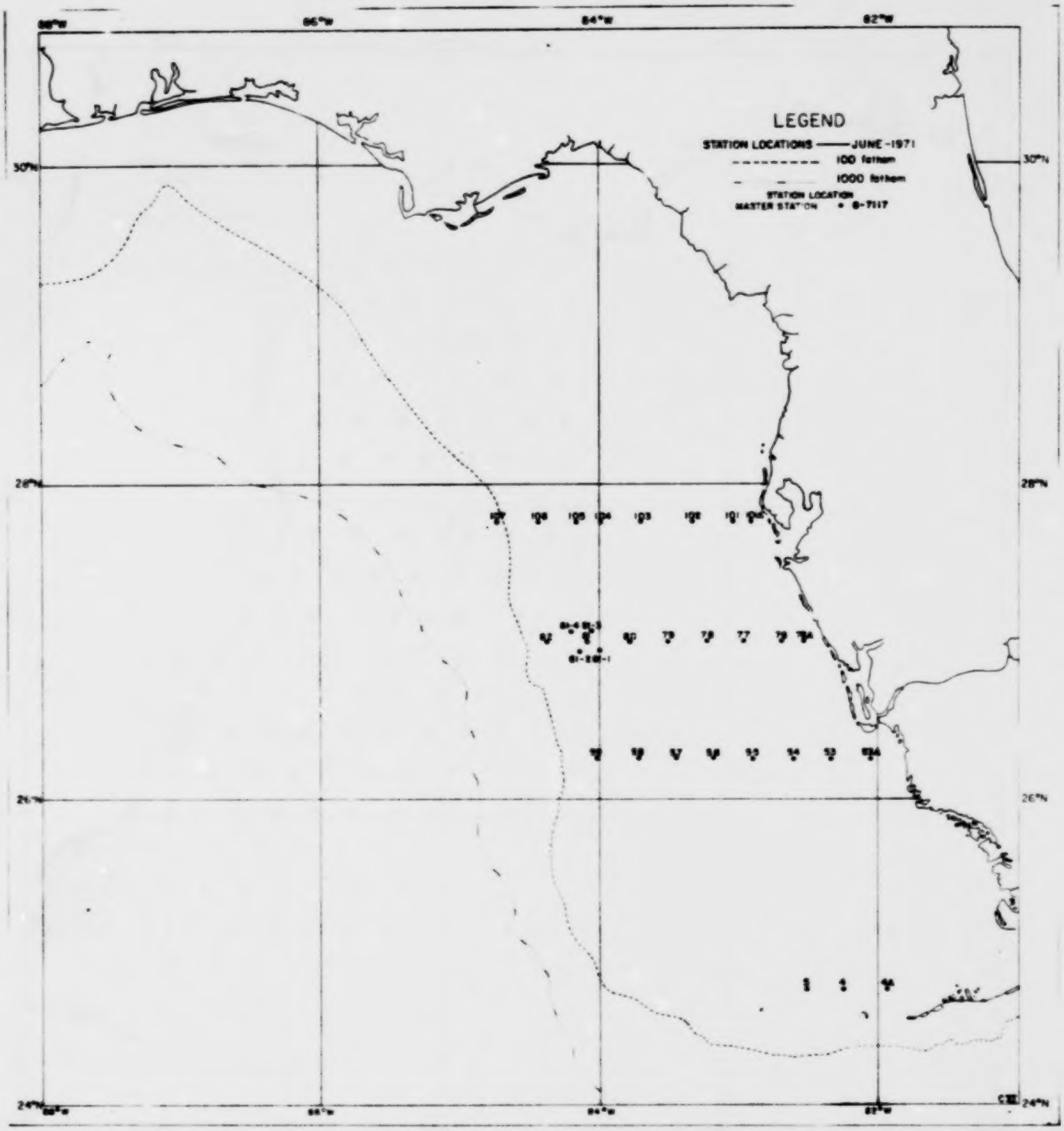
ESCAROSA I - SEPTEMBER 14-16, 1971

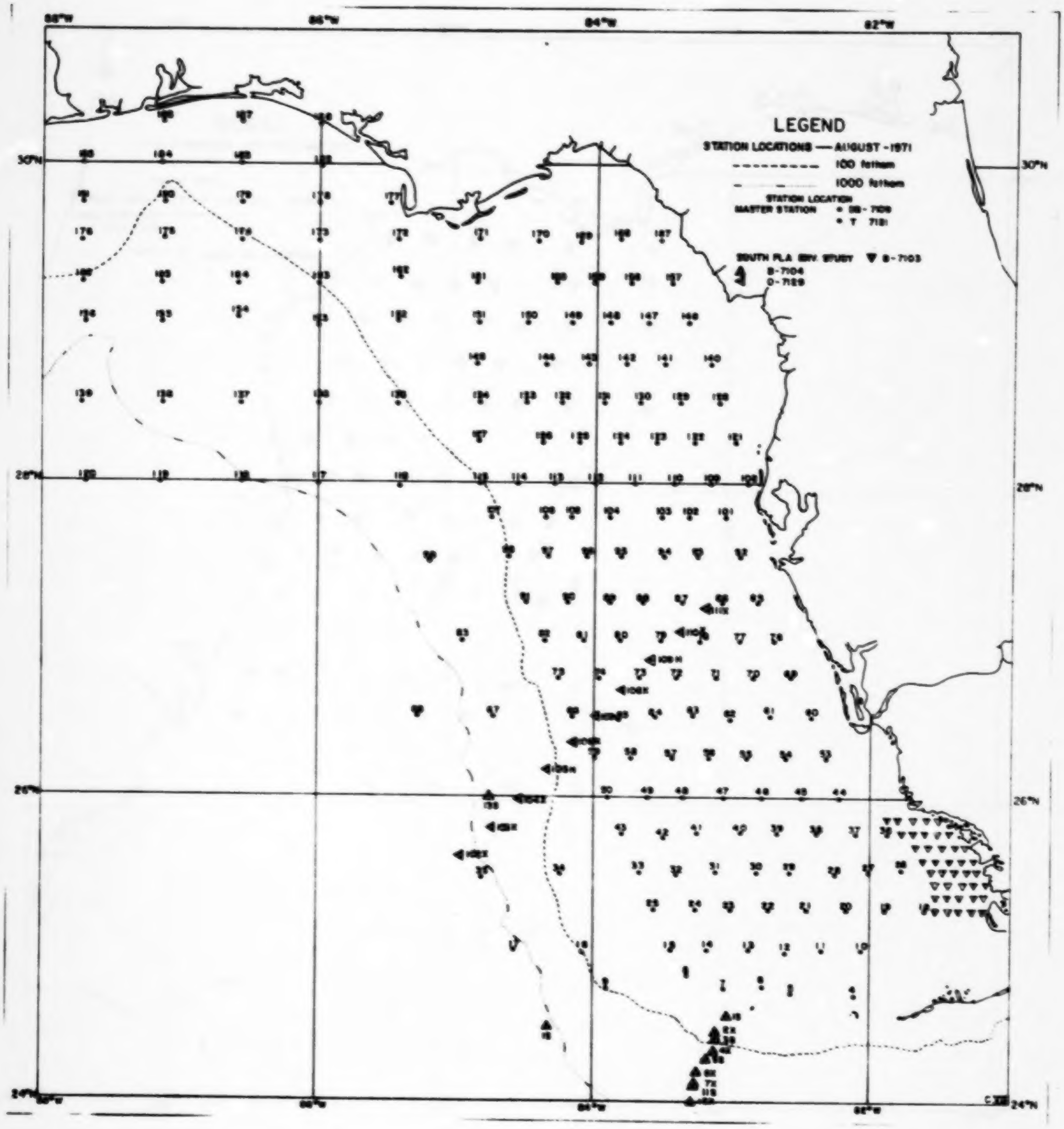
CIV


LOCATION OF STATIONS WITHIN WESTERN CONTINENTAL SHELF PROGRAM OPERATIONAL AREA
EGMEX III - OCTOBER 23 - NOVEMBER 4, 1970
LEGEND
100 fathom
1000 fathom
STATION LOCATION
IW-7007
T -7020
J -7014
88°W
86°W
84°W
82°W
30°N
28°N
26°N
24°N

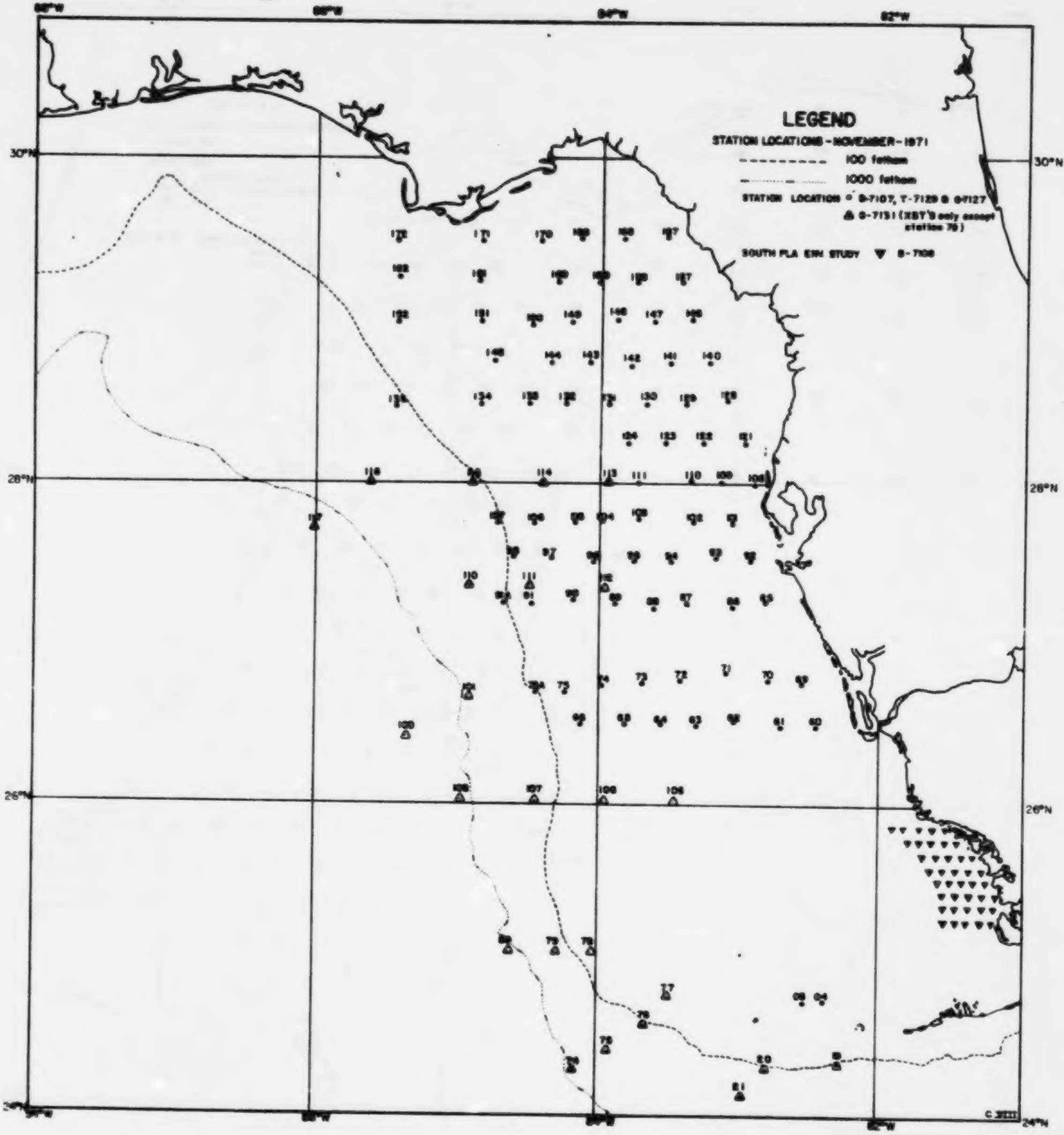

88°W
86°W
84°W
82°W
30°N
28°N
26°N
24°N
LEGEND
STATION LOCATIONS —— MAY - 1971
- - - - - - - - - - 100 fathom
— — 1000 fathom
STATION LOCATION • MASTER STATION
DB-7103 & T-7114
SOUTH FLA ENV STUDY ▼ B-7102
▲ T-7114

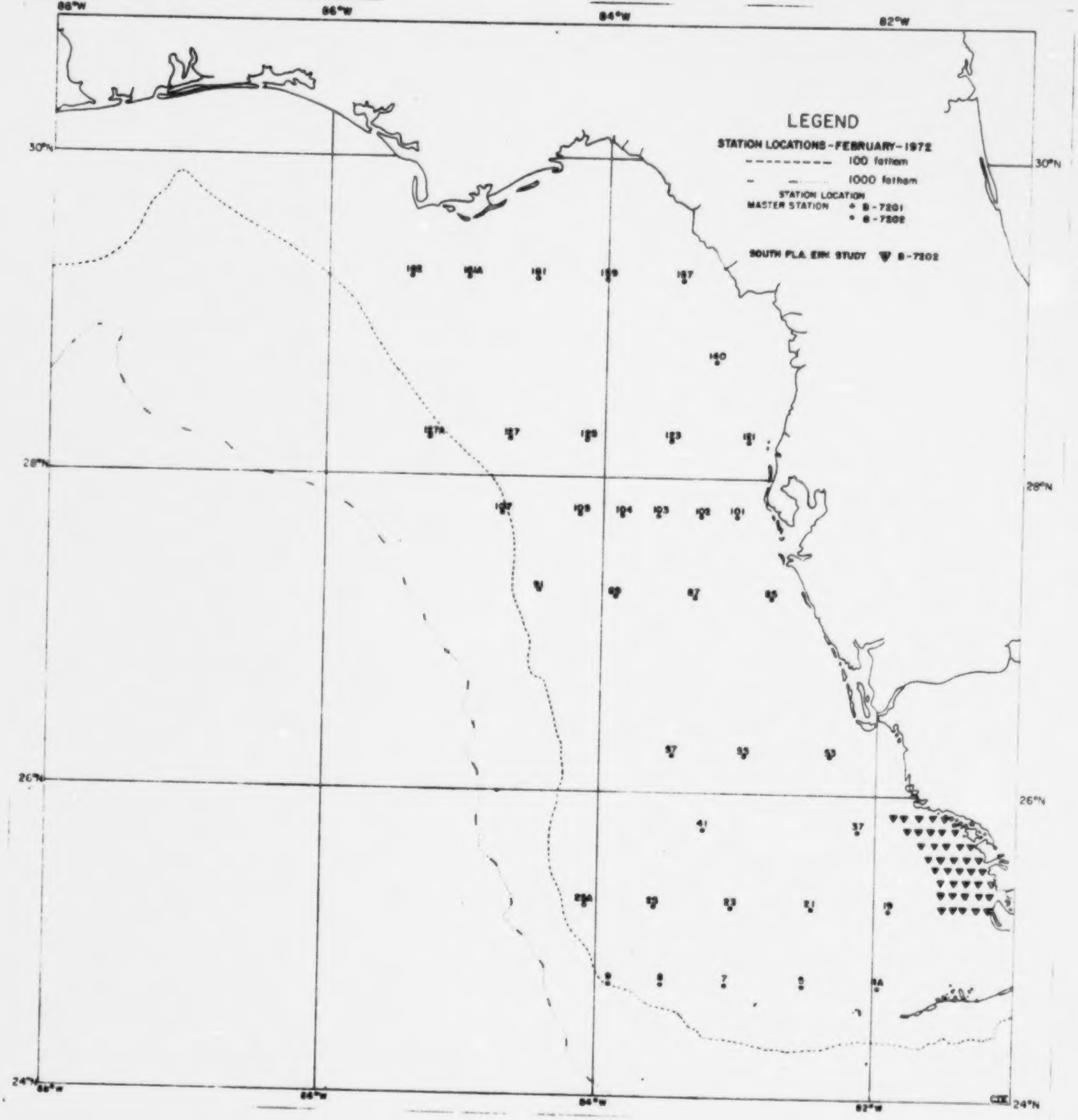
CVI


88°W
86°W
84°W
82°W
30°N
28°N
26°N
24°N
LEGEND
STATION LOCATIONS —— JUNE-1971
100 fathom
1000 fathom
STATION LOCATION
MASTER STATION • B-7117
107
106
105
104
103
102
101
100


88°W
86°W
84°W
82°W
30°N
28°N
26°N
24°N
LEGEND
STATION LOCATIONS — AUGUST - 1971
100 fathom
1000 fathom
STATION LOCATION
MASTER STATION
● DB - 7109
● T 7131
SOUTH FLA. ENV. STUDY ▼ B - 7103
B - 7104
D - 7129

C VIII


88°W
86°W
84°W
82°W
30°N
28°N
26°N
24°N
LEGEND
STATION LOCATIONS - NOVEMBER - 1971
100 fathom
1000 fathom
STATION LOCATION ● B-7107, T-7129 & B-7127
▲ B-7131 (XBT'S only except station 79)
SOUTH FLA ESN STUDY ▼ B-7108
C VIII


LEGEND
STATION LOCATIONS - FEBRUARY - 1972
100 fathom
1000 fathom
STATION LOCATION
MASTER STATION
B - 7201
B - 7202
SOUTH FLA. ENV. STUDY
B - 7202
88°W
86°W
84°W
82°W
30°N
28°N
26°N
24°N
160
104
103
101
41
37
23
21
7
CIX

Tidal Currents on the West Florida Shelf

Harold O. Mofjeld
NOAA/Atlantic Oceanographic and Meteorological Laboratories
Miami, Florida

Much of the water motion on the West Florida Shelf is due to the tides. Perhaps the most familiar examples of tidal currents are the currents at the mouths of harbors. These currents are caused by the differences in water level between the water on the continental shelves outside the harbor and the water within the harbors. On the West Florida Shelf and in the deep water beyond, similar tidal currents exist because of differences in sea level caused by the tides. As will be discussed later, there are two other kinds of currents which resemble the familiar tidal currents and which can make important contributions to the water motions on the shelf.

The tides in the Gulf of Mexico originate in the Atlantic Ocean. It propagates as a wave into the Gulf where it has a very complicated but poorly described distribution. Tides are composed principally of a semidaily part with a period of about 25 hours. As seen in the Tide Tables, published by the Department of Commerce, the tides along the East Coast of the United States are semidaily. At the southern limit of the West Florida Shelf, Key West has a semidaily tide; the range of the tide is small compared with representative tides along the East Coast. Along the West Coast of Florida, the tides change becoming more daily toward the north. At Pensacola, the tide is almost purely daily. The transition does not proceed smoothly up the coast as shown by Zetler and Hansen (1972) in their description of tides in the Gulf of Mexico. Apalachicola Bay has a profound effect on the tides, a phenomenon not well understood.

Theoretical models of the tides in the Gulf, such as the model described by Mihkaylov *et al*. (1969), which predict the distributions of tides are available. Observations of pressure, made by AOML using a bottom-mounted pressure gage in the middle of the Gulf, indicate that the general features of Mihkaylov's model are at least correct for the semidaily tide in deep water. Much work, both making observations and developing models, must be done before the tides which drive tidal currents on the West Florida Shelf are adequately described.

If the currents on the shelf were due solely to the vertical movements of the sea surface associated with the tides, the currents would be as regular and predictable as the tides. Unpublished current observations at 26° N on the West Florida Shelf, made by Prof. C.N.K. Mooers and others at the University of Miami/RSMAS and NOVA University, show that the currents with periods of half a day to a day are irregular.

These currents consist of not only tidal currents but also internal waves of tidal period and inertial currents caused by the winds. The latter two types of motions are responsible for this irregularity.

From the middle of spring until the middle of autumn, the water over much of the West Florida Shelf consists of a well-mixed surface layer of low density and a well-mixed, heavier layer underneath. Separating these two layers is a thin layer, called a pycnocline, in which the density of the water increases rapidly with depth. Undulations in this pycnocline are created at the shelf break by the tidal currents moving water on and off the shelf. These undulations propagate as internal waves toward shore from the shelf break. Since they have the same period as the tide, they are often called internal tides.

A clear example of internal tides off Panama City, Florida, was observed and reported by Boston (1964). During three days of observation, the pycnocline was seen to undulate with the period of the daily tides. Since the shelf is narrow at Panama City, the internal tide reflected off the nearshore bottom topography and formed a seaward propagating wave. Elsewhere on the West Florida Shelf where the pycnocline disappears seaward of the nearshore region, no reflected wave would be produced. Instead, the shoreward propagating internal tide is dissipated entirely into turbulence, probably where the water column becomes vertically homogeneous.

As the pycnocline moves up and down, it induces currents of tidal period in the surface and bottom layers. The currents in these two layers are opposite in direction. The current in each layer rotates in direction during the tidal cycle because of earth's rotation. Since the pycnocline is seasonal, currents due to internal tides are also seasonal. When the pycnocline over most of the shelf disappears in the fall, the internal tides also disappear. However, during much of the year, particularly on the outer shelf, internal tidal currents are probably a significant part of the total current regime.

Whenever the wind blowing over the sea surface changes either in intensity or in direction, it induces near-surface currents which rotate in time. The sense of rotation is clockwise, looking down on the sea surface, in the northward hemisphere. The period of these inertial currents, as they are called, in the Gulf of Mexico is very close to the period of the daily tide. If the changes in the wind are sufficiently strong, the resulting inertial currents can exceed the tidal currents on the shelf. An example of storm-induced currents can be seen in unpublished current observations made by AOML off the West Florida Shelf. Current measurements near the surface clearly show inertial currents generated by the passage of a tropical storm. Rotatory currents with the inertial period appeared and then decayed with time. This decay in the inertial current's intensity was probably due to three processes which affect inertial currents. Since inertial currents have some wave-like attributes, some of the motion propagates away from the generation region. Turbulence causes the near-surface motion to diffuse downward so that the inertial motion is no longer concentrated near the surface. Finally, this same turbulence dissipates the motion.

These three processes, propagation, vertical diffusion, and dissipation, also affect inertial currents on the West Florida Shelf. The motion is further complicated on the shelf by the effects of shallow and variable water depth and by the presence of the coast. Since strong wind events, tropical storms, hurricanes, and cold fronts occur frequently on the West Florida Shelf, inertial currents can be expected to occur often with considerable intensity in this region.

At least conceptually, the shelf may be subdivided into smaller regions, more or less parallel to shore, in which the composition and characteristics of the tidal and inertial currents differ. Near the shelf break, the tide makes a transition from the deep sea to the shelf. Throughout the year, the water in the immediate vicinity of the shelf break and seaward tends to be vertically stratified. The motion of the tides on and off the shelf therefore generates internal tides during the entire year.

During the summer regime when the water is stratified over much of the shelf, these internal tides propagate from the shelf break across the outer shelf toward shore. In the middle shelf, the density stratification may disappear; and the internal tides cannot propagate into this region. Nearshore, the presence of the shore and inlets strongly affects tidal and inertial motions. Density stratification also affects the vertical distribution of inertial currents; and the different density regimes on the shelf therefore also apply to inertial currents. In general, internal tides and inertial currents on the shelf are seasonable. Currents associated with the surface tides, on the other hand, persist throughout the year.

There are very few direct measurements of currents on the West Florida Shelf. The measurements which do exist are limited to the Panama City area in the north and the southern section of the shelf around 26° N. The current regime over most of the West Florida Shelf is unexplored; the discussion above is necessarily qualitative. Before quantitative estimates can be made and before the distribution of currents throughout the year can be described for the West Florida Shelf, a great deal of field work must be done. Hopefully, this work will be done in the near future. Associated with field observations should be the development of models, first descriptive and then predictive, to compute the currents on the shelf, using a small number of field data. The number of expensive monitoring stations could then be kept to a minimum.

Bibliography

Boston, N. E. J. 1964. Observations of tidal periodic internal waves over a three day period off Panama City, Florida, Texas A and M University, Department of Oceanography and Meteorology Report, Reference 64-20T.

Mihkaylov, Yu. D., Meleshko, V. P., and Shcheveleva, G. I. 1969. Calculation of the Tides and Tidal Currents in the Gulf of Mexico and the Caribbean Sea, Trudi, Govt. Oceanog. Inst., 96: 146-173.

Zetler, B. D. and Hansen, D. V. 1972. Tides in the Gulf of Mexico, Contributions on the Physical Oceanography of the Gulf of Mexico, Texas A and M University Oceanographic Studies, Vol. 2, Gulf Publishing Co., Houston, Texas, pp. 265-275.

Response of the West Florida Shelf Circulation to Strong Meteorological Forcing

Christopher N. K. Mooers
University of Miami
Rosenstiel School of Marine and Atmospheric Science

Introduction

The overall experimental schedule and data harvest are summarized in Tables 1 and 2. For simplicity, only a few results from the Winter 1973 Experiment are discussed. A current meter array, distributed horizontally and vertically, formed the core of the experiment (Fig. 1.). The array was designed to study the propagation of barotropic and baroclinic waves, with tidal and several-day time scales. It was designed to also define the circulation during the experimental period and the coherence scales of the variability field. The experimental chronology is summarized in Fig. 2. In addition, a large number of hydrographic and meteorological data were acquired through and around the array site.

Mean Circulation

The mean circulation and temperature field are summarized in Fig. 3. There was a general tendency for the mean velocity to parallel the isobaths. On the inner shelf (depth less than 100 m), the velocity was southward; on the outer shelf (depth greater than 100 m but less than 200 m), the velocity was northward. At the break between the inner and outer shelves (depth equal to 100 m), the shallower currents were southward while the deepest currents had a northward component. The sense of the vertical shear - i.e., increasing northward with depth - at all positions between the 100 and 200 m isobaths was consistent, through the thermal wind relation, with the shoaling of the thermocline from deep to shallow water (shown, for example, in Fig. 4).

Variable Circulation

A general idea of the nature of the variable component of the circulation field can be deduced from the progressive vector diagrams, Figs. 5, 6, and 7. Each depth domain had its own characteristic variability. On the inner shelf, a single, major, barotropic reversal occurred; on the outer shelf and at the break between the inner and outer shelf, the most variability (i.e., several reversals containing baroclinic components) was observed. At the outer shelf break (depth 200 m), one large rotation occurred with a period of about two weeks. It rotated clockwise at mid-depth and anticlockwise near the bottom!

Meteorological Conditions

Time series of the basic meteorological variables at the center of the array site show the passage of five cold fronts of varying intensities during the experimental period (Fig. 8). While a climatology of cold fronts in the Gulf of Mexico does not seem to exist, conventional wisdom holds that the meteorological conditions experienced are representative of the winter season, October through March. Since maximum wind speeds are associated with cold fronts, it is to be expected that the most intense air-sea exchanges occur with their passages. Furthermore, since the cold fronts are the principal seasonal meteorological events in this area, much of the seasonality of the density stratification and circulation is probably produced by their cumulative effect. It is also reasonable to expect that the first powerful cold front of the season is likely to produce the most dramatic effects.

Response to the Cold Front of 9 and 10 February 1973

The passage of the strongest cold front of the experimental period occurred on 9 and 10 February 1973. The discussion of the response will be limited to data from a Cyclesonde station at the outer shelf break. A Cyclesonde is an autonomous variable buoyancy device for sampling time series of vertical profiles of horizontal velocity and temperature (see Van Leer et al., 1973, for a description of the system, which has been largely developed under this program). Contours of the data obtained from 265 Cyclesonde profiles (sampled half-hourly and at 5-meter vertical increments) reveal a complex vertical and temporal structure Fig. 9). Before the passage of the 9 - 10 February cold front, the surface and bottom mixed layers were becoming thinner and warmer, presumably as part of the "recovery" from the previous cold front passage. After the cold front passage on 9 and 10 February, the surface and bottom boundary layers became thicker and cooler again. The velocity field generally showed considerable baroclinic noise on a tidal time scale. Of great interest is the generation of an intense, baroclinic, clockwise, inertial (period of about 27 hours) oscillation in the upper 50 m during the passage of the cold front. Finally, the mean velocity and temperature profiles (Fig. 10) for each of the two Cyclesonde segments (before and after the cold front passage) reveal the following: (1) the alongisobath flow became more baroclinic with the frontal passage, (2) the transisobath flow became one-celled rather than two-celled and was consistent with wind-induced coastal upwelling, i.e., offshore Ekman drift in the surface layer and onshore flow in the lower layer, (3) the maximum mean velocity occurred at the top of the thermocline in both cases, (4) virtually the entire water column was cooled by an average of 1^{o}C, (5) the turbulent intensity (ration of r.m.s. to mean velocity) was of order one and nearly horizontally isotropic except near the surface, and (6) the r.m.s. velocity became substantially more uniform with depth after the frontal passage.

Summary

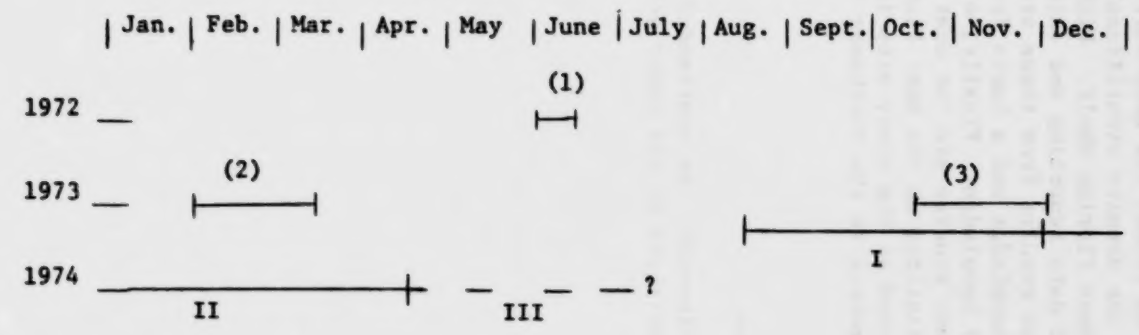
The results presented here are only a small fraction of those in hand. It is already clear that the level of variability on the West Florida Shelf was high, the experimental design was effective for revealing the space-time structure of the dynamic variables, and the influence of meteorological events (as well as tides, the Loop Current, etc.) must be accounted for in understanding the density stratification, circulation, and exchange processes on the West Florida Shelf. With a substantial funding increment, the rate of data reporting and data digestion could be substantially accelerated. The results from these studies can be counted upon to provide new, basic knowledge and a basis for planning future studies and derivative (applied) knowledge. Finally, with little doubt, it is safe to say that the present studies are the most comprehensive investigations of physical variability on the West Florida Shelf and that the field of variability observed at the array site is likely to be representative of that found elsewhere in the Northeast Gulf of Mexico.

Reference

Van Leer, J. C., *et al*. 1973. The Cyclesonde: an unattended vertical profiler for scalar and vector quantities in the upper ocean. Deep-Sea Res. Vol. 20.

Table 1

Overall Experimental Schedule



(1) Pilot Study

(2) Winter Experiment

(3) Autumn Experiment

I, II, III Shelf Wave and Monitoring Experiment

Table 2

Data Harvest

(1) Pilot Study June 1972

(2) Winter 1973 Experiment

(3) Autumn 1973 Experiment

I Shelf Wave and Monitoring Experiment August to December 1973

II,III Shelf Wave and Monitoring Experiment December 1973 to ?

	(1)	(2)	(3)	I	II III	Total
STD (Casts)	156*	223*	~250#			629
XBT (Casts)	105*	195*	~50			350
O_2 (Samples)	---	200*	~50*			250
Cyclesonde (Profiles)	940# ~250*	2,800# ~300*	~2,000			5740
APCM (Profiles)	160#	10*	0			170
Fixed-level CM (No. Days)	(4 of 6) x 8* = 32	(13 of 13) x 29* = 288	(12 of 15) x 45 = 540	967		1827
Inclinometer String (Days)	6	12	missing			18
Meteorological Data	Ship	Ship/synoptic charts	Ship			
Other	GEK, Thermo-salinograph	NDBC Meteorological buoys	---			

# Reduced
* Processed to some extent

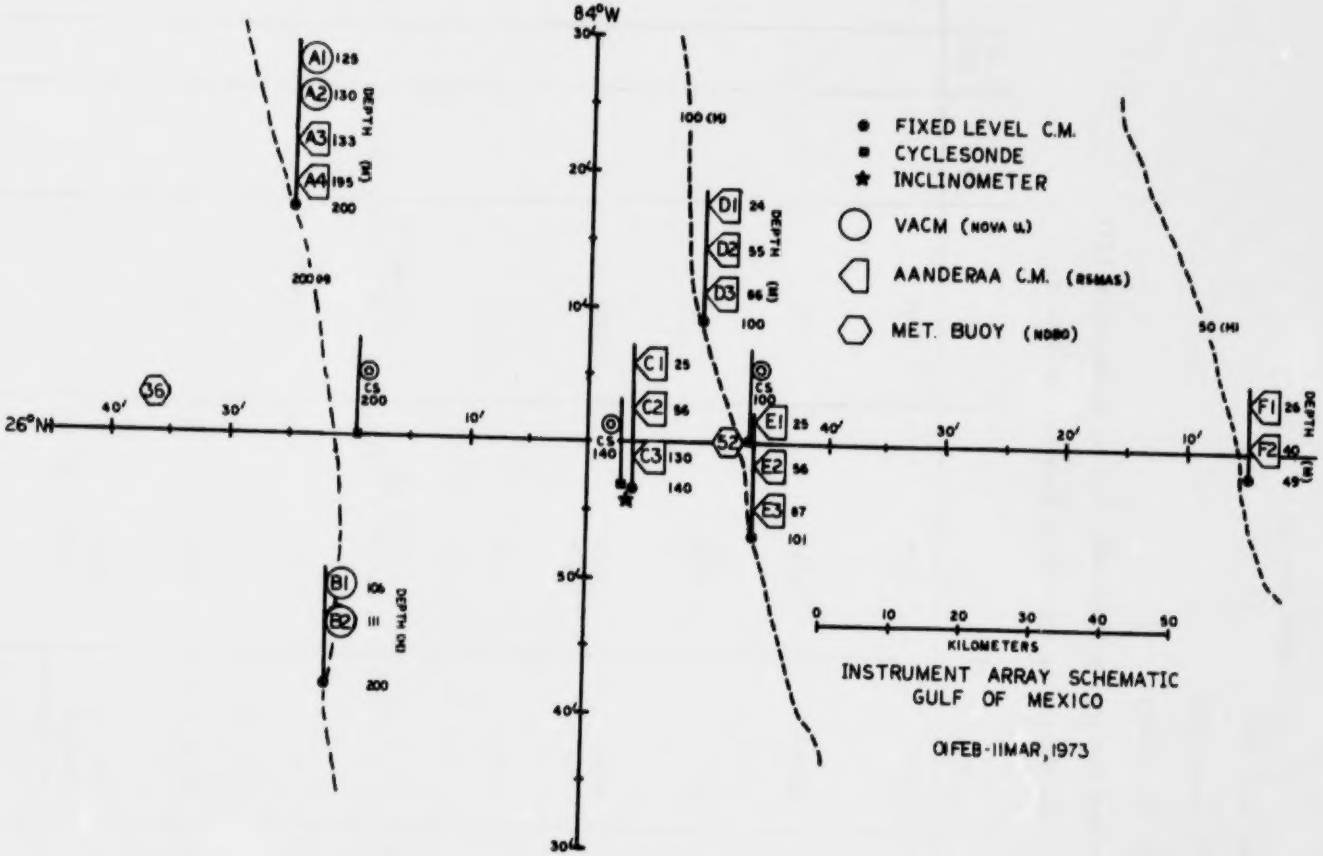
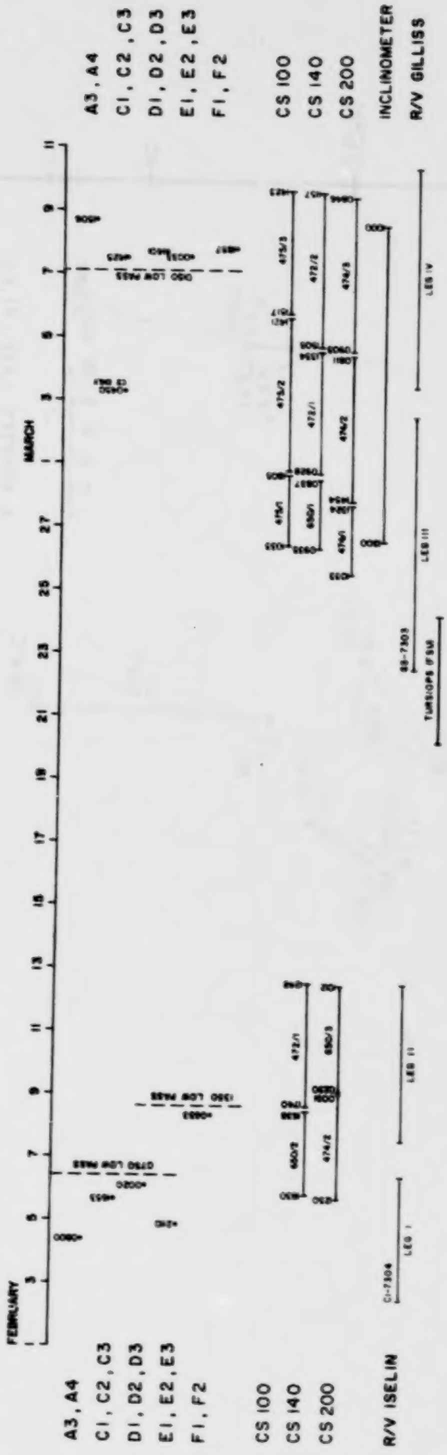

84°W
26°N
30'
20'
10'
50'
40'
FIXED LEVEL C.M.
CYCLESONDE
INCLINOMETER
VACM (NOVA U.)
AANDERAA C.M. (RSMAS)
MET. BUOY (NDBO)
A1 125
A2 130
A3 133
A4 195
200
DEPTH (M)
200 (M)
B1 106
B2 111
200
DEPTH (M)
CS 200
36
CS 140
C1 25
C2 56
C3 130
140
100 (M)
D1 24
D2 55
D3 86
100
DEPTH (M)
52
CS 100
E1 25
E2 56
E3 87
101
50 (M)
F1 26
F2 40
49
DEPTH (M)
0 10 20 30 40 50
KILOMETERS
INSTRUMENT ARRAY SCHEMATIC
GULF OF MEXICO
01FEB-11MAR, 1973

FIGURE 1.



A3, A4
C1, C2, C3
D1, D2, D3
E1, E2, E3
F1, F2
CS 100
CS 140
CS 200
R/V ISELIN
INCLINOMETER
R/V GILLISS
FEBRUARY
MARCH
1
3
5
7
9
11
13
15
17
19
21
23
25
27
1
3
5
7
9
11
0730 LOW PASS
1350 LOW PASS
0150 LOW PASS
LEG I
LEG II
LEG III
LEG IV
CI-7304
GS-7303
TURSIOPS (FSU)
475/1
475/2
475/3
472/1
472/2
474/1
474/2
474/3
650/2
650/3

FIGURE 2.

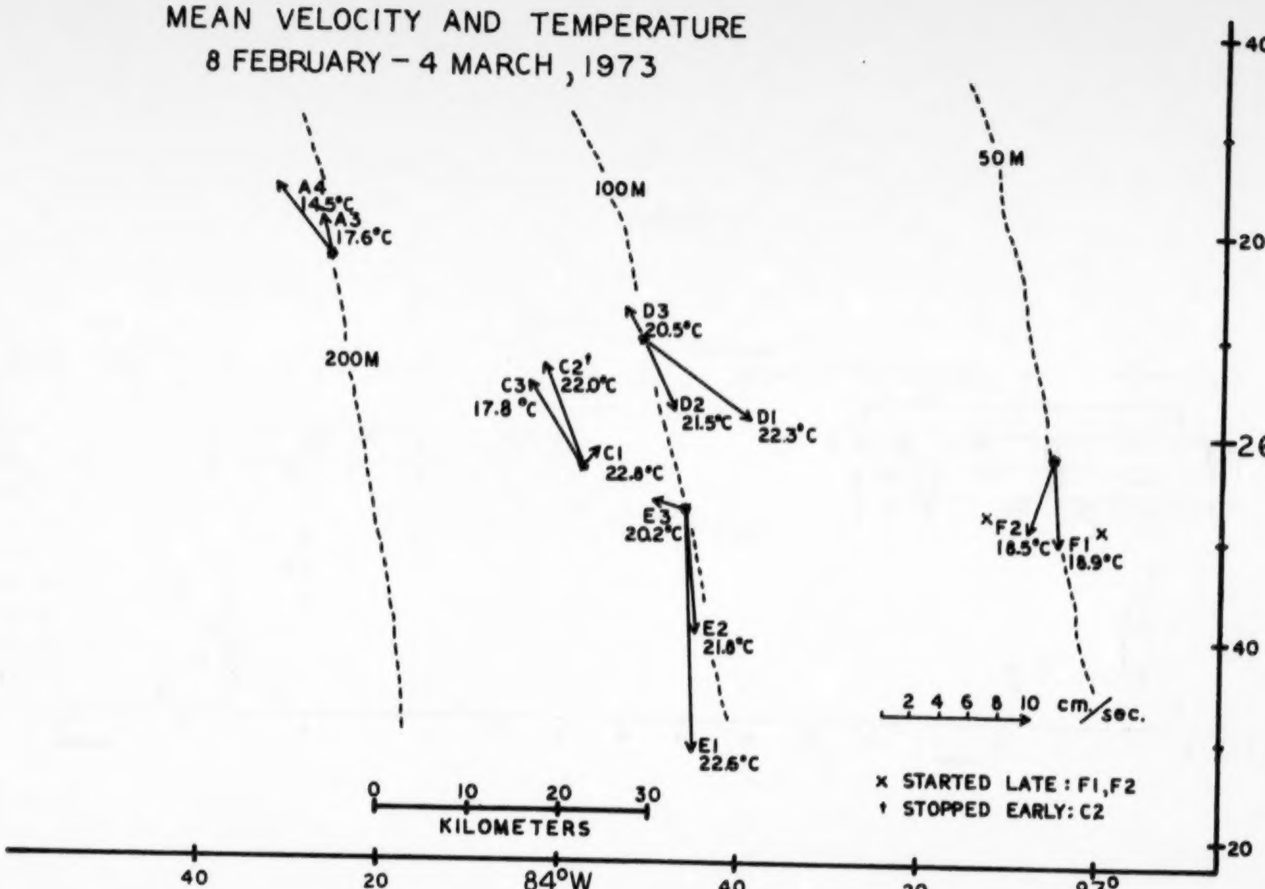

MEAN VELOCITY AND TEMPERATURE
8 FEBRUARY - 4 MARCH, 1973
200M
100M
50M
A4
14.5°C
A3
17.6°C
C3
17.8°C
C2†
22.0°C
C1
22.8°C
D3
20.5°C
D2
21.5°C
D1
22.3°C
E3
20.2°C
E2
21.8°C
E1
22.6°C
×F2
18.5°C
F1×
18.9°C
2 4 6 8 10 cm/sec.
× STARTED LATE: F1, F2
† STOPPED EARLY: C2
0 10 20 30
KILOMETERS
40
20
84°W
40
20
83°
40
20
26°N
40
20

FIGURE 3.

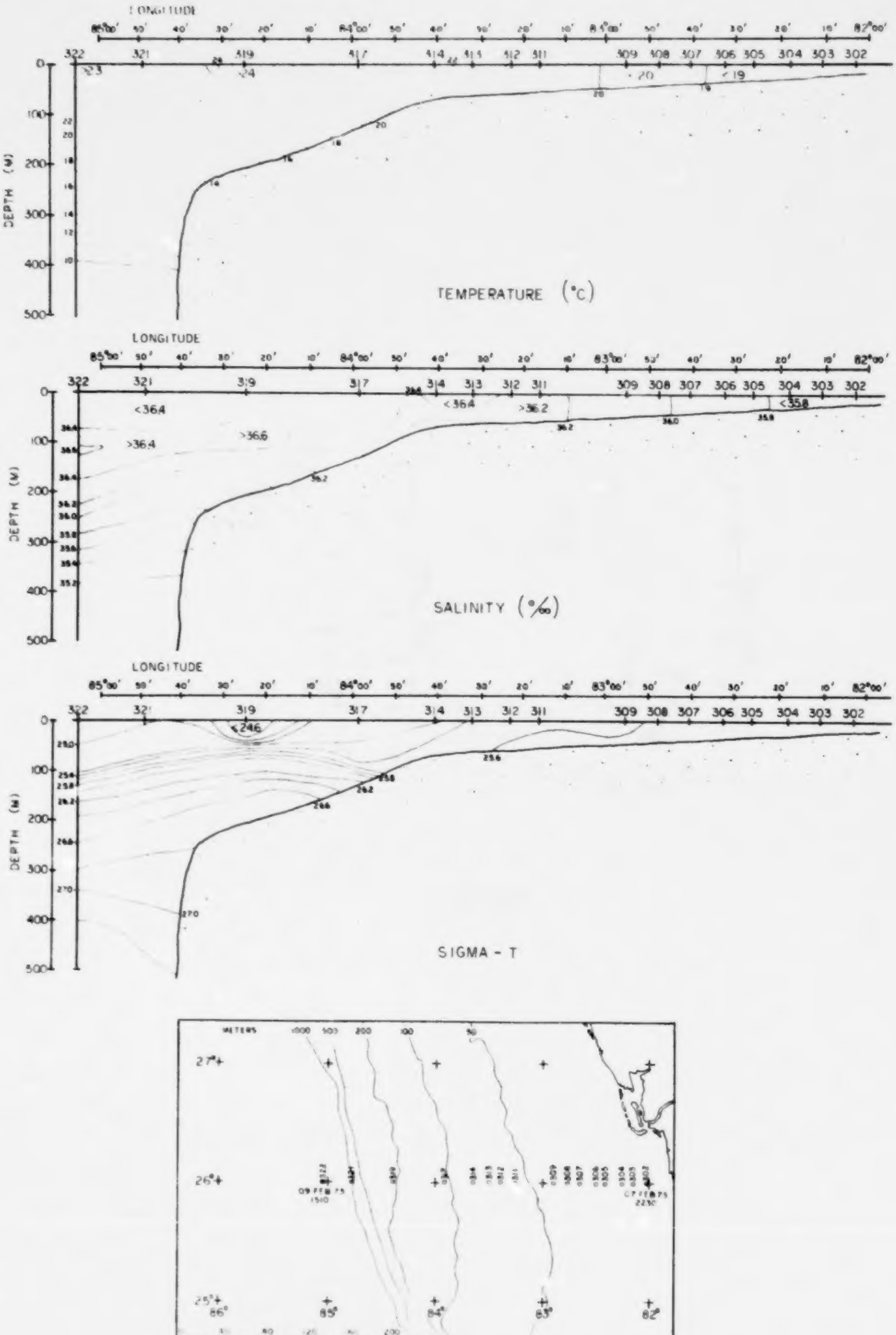

LONGITUDE
85°00'
50'
40'
30'
20'
10'
84°00'
83°00'
82°00'
322
321
319
317
314
313
312
311
309
308
307
306
305
304
303
302
DEPTH (M)
0
100
200
300
400
500
<23
<24
<20
<19
TEMPERATURE (°C)
<36.4
>36.4
>36.6
<36.4
>36.2
<35.8
SALINITY (‰)
<24.6
SIGMA - T
METERS
1000
500
200
100
50
27°
26°
25°
86°
85°
84°
83°
82°
09 FEB 75
1510
07 FEB 75
2230
KM

FIGURE 4.

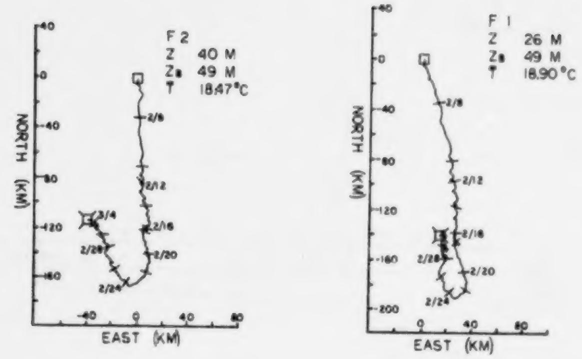

F 2
Z 40 M
ZB 49 M
T 18.47°C
NORTH (KM)
40
0
-40
-80
-120
-160
EAST (KM)
-40
0
40
80
2/8
2/12
2/16
2/20
2/24
2/28
3/4
F 1
Z 26 M
ZB 49 M
T 18.90°C
NORTH (KM)
40
0
-40
-80
-120
-160
-200
EAST (KM)
0
40
80
2/8
2/12
2/16
2/20
2/24
2/28

FIGURE 5.

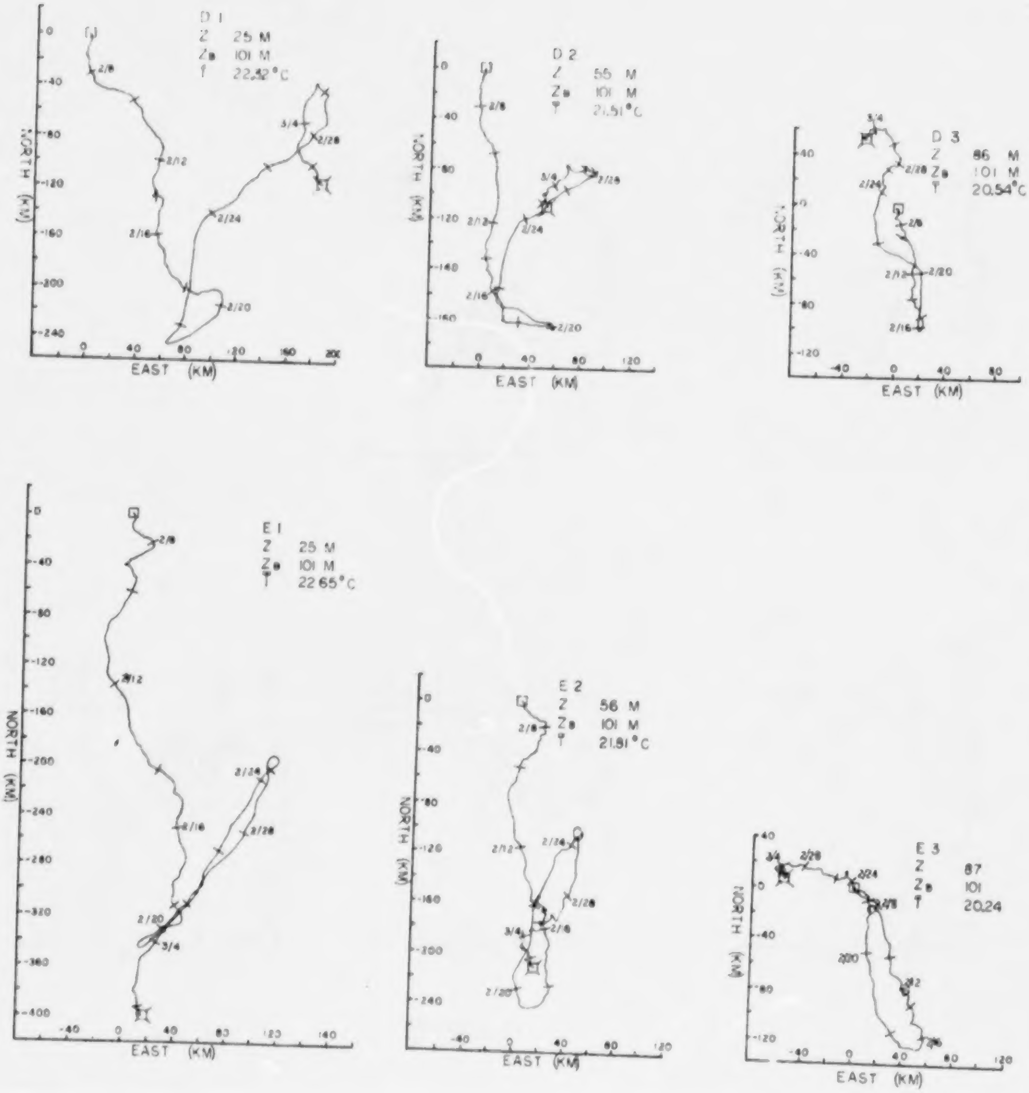
D 1
Z 25 M
Z_B 101 M
T 22.32°C
D 2
Z 55 M
Z_B 101 M
T 21.51°C
D 3
Z 86 M
Z_B 101 M
T 20.54°C
E 1
Z 25 M
Z_B 101 M
T 22.65°C
E 2
Z 56 M
Z_B 101 M
T 21.81°C
E 3
Z 87
Z_B 101
T 20.24
NORTH (KM)
EAST (KM)
2/8
2/12
2/16
2/20
2/24
2/28
3/4

FIGURE 6.

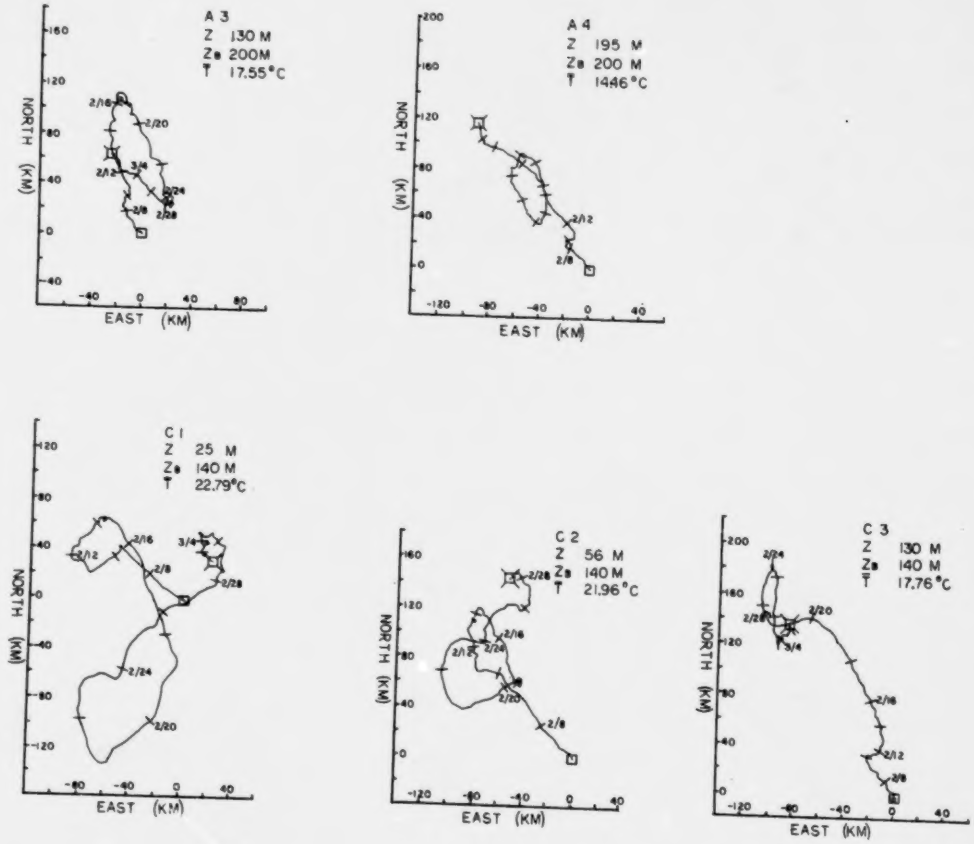

A 3
Z 130 M
Zв 200M
T̄ 17.55°C
A 4
Z 195 M
Zв 200 M
T̄ 14.46°C
C 1
Z 25 M
Zв 140 M
T̄ 22.79°C
C 2
Z 56 M
Zв 140 M
T̄ 21.96°C
C 3
Z 130 M
Zв 140 M
T̄ 17.76°C
NORTH (KM)
EAST (KM)
2/8
2/12
2/16
2/20
2/24
2/28
3/4

FIGURE 7.

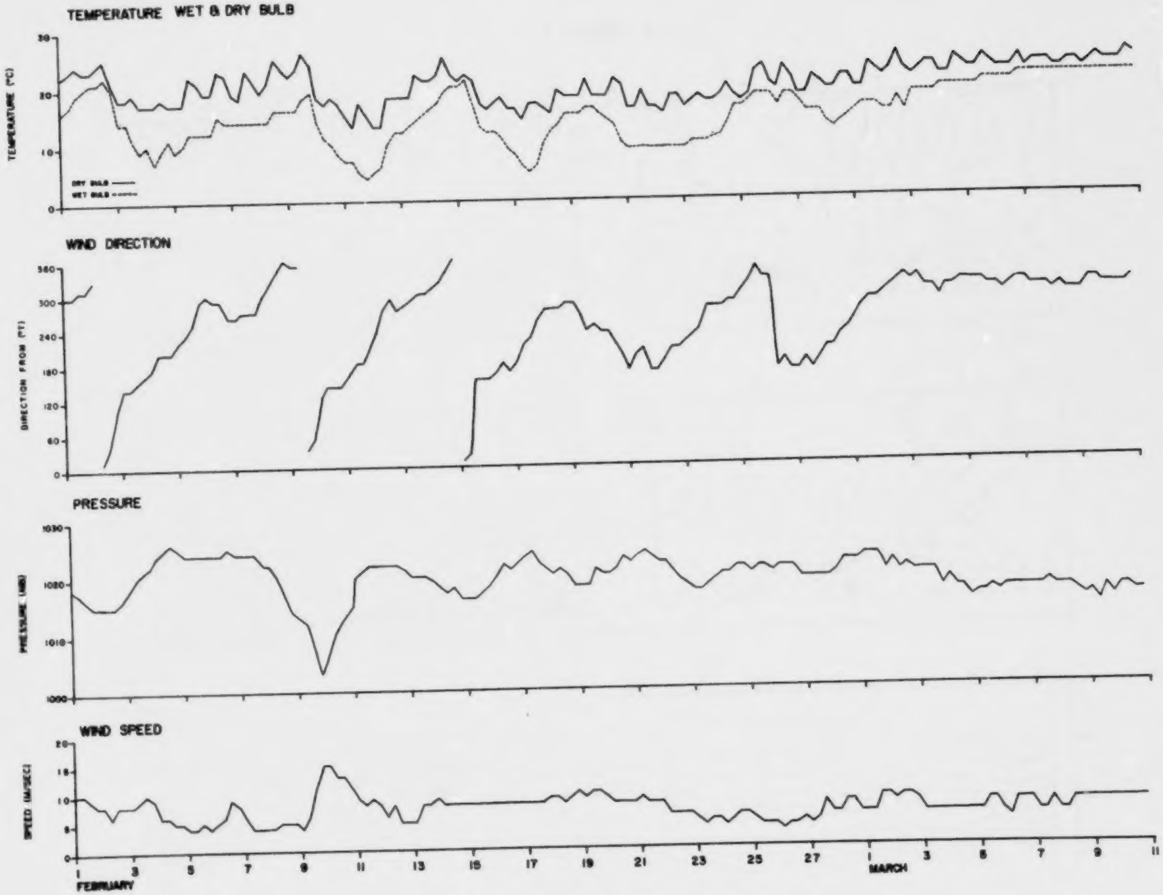

TEMPERATURE WET & DRY BULB
TEMPERATURE (°C)
30
20
10
0
DRY BULB
WET BULB
WIND DIRECTION
DIRECTION FROM (°T)
360
300
240
180
120
60
0
PRESSURE
PRESSURE (MB)
1030
1020
1010
1000
WIND SPEED
SPEED (M/SEC)
20
15
10
5
0
1
3
5
7
9
11
13
15
17
19
21
23
25
27
1
3
5
7
9
11
FEBRUARY
MARCH

FIGURE 8.

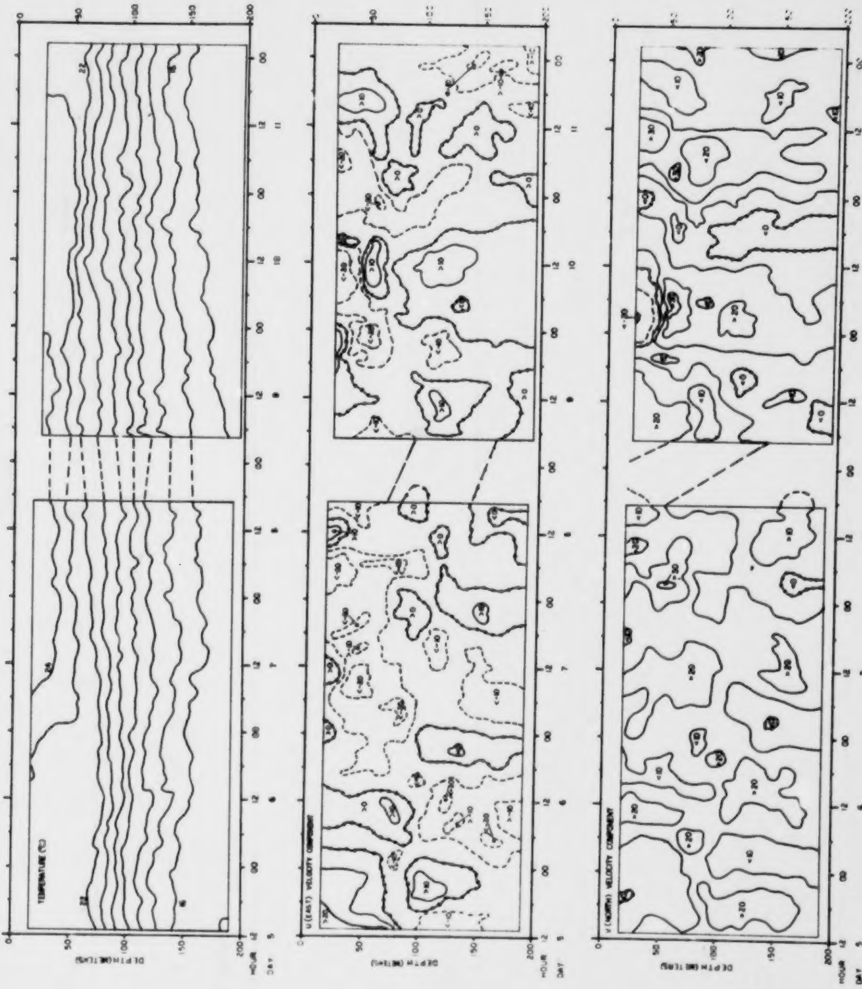

TEMPERATURE (°C)
U (EAST) VELOCITY COMPONENT
V (NORTH) VELOCITY COMPONENT
DEPTH (METERS)
HOUR
DAY

FIGURE 9.

FIRST SHELF BREAK CYCLESONDE STATION - FEBRUARY 1973

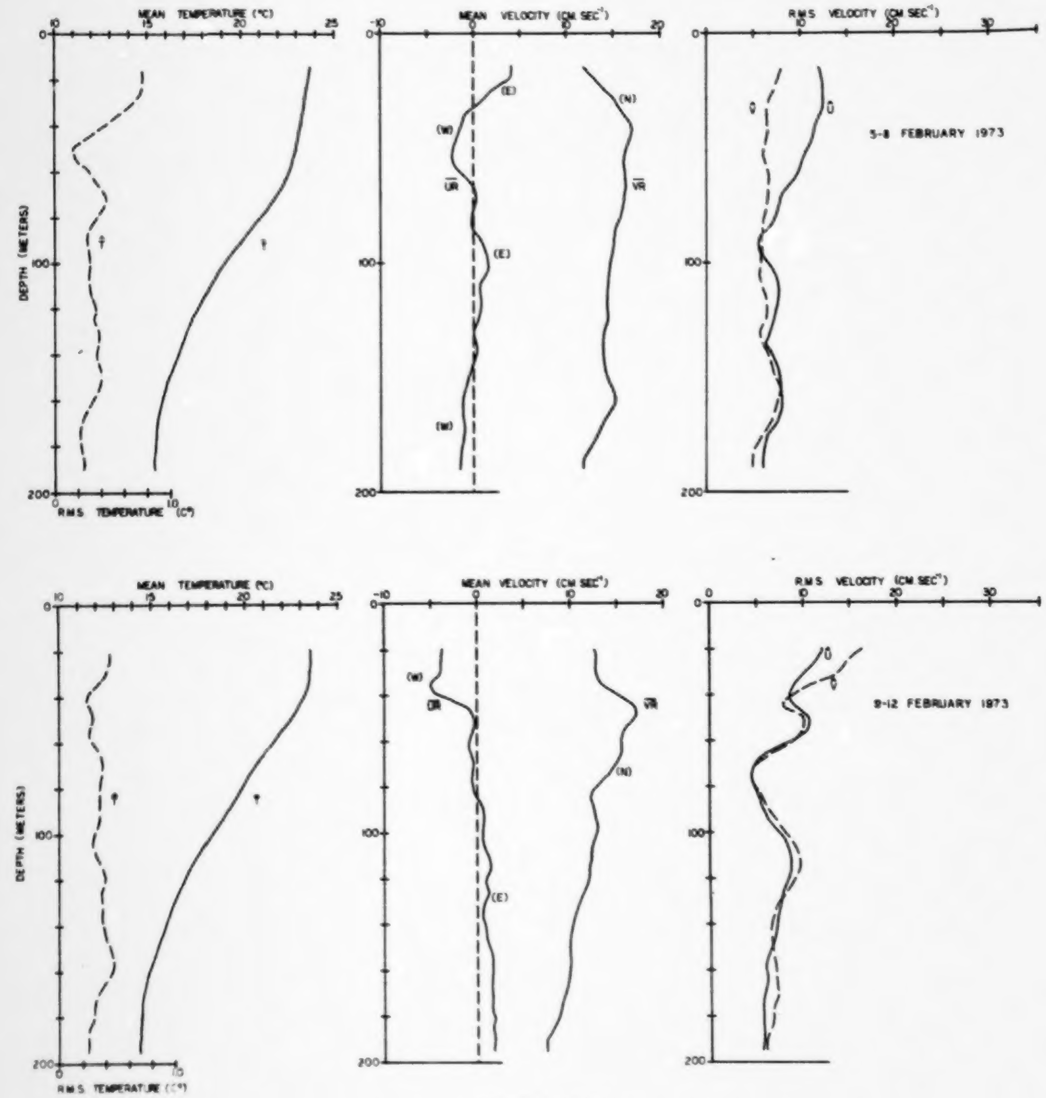


FIGURE 10.

Biological Oceanography

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Seagrasses

Harold J. Humm
Department of Marine Science
University of South Florida
St. Petersburg, Florida

The inner part of the great continental shelf along the Florida Gulf coast supports the most extensive seagrass beds of the continent of North America. A major stand of these seagrasses occurs from Tarpon Springs northward to Port St. Joe of the Florida panhandle in subregion C of Earle (1969), an area in which the seagrass beds are essentially continuous for a distance of about 250 miles. The gentle slope of the inner shelf in this area is such that these seagrass beds are more than ten miles wide in many places, extending from the intertidal zone out to depths of six to eight meters or more (Humm 1973).

Three species (perhaps four, if den Hartog, 1970, is followed) make up about 99 percent of the biomass of these seagrass beds: *Thalassia testudinum* König and Sims, *Syringodium filiforme* Kützing in Hohenacker, and *Halodule wrightii* Ascherson (*Diplanthera wrightii* [Ascherson] Ascherson). The relative abundance of these three species is presumed to be in the order given above, based upon general observations of the beds and of the quantity of leaves washed ashore. Quantitative data are available from only a few small areas (Zimmerman, Feigl, Ballantine, and Humm; Ballantine and Humm; *in*:Baird *et al*., 1972) and are not adequate for interpolation to include large areas.

A fourth species, *Halophila engelmannii* Ascherson in Neumayer, occurs in the beds mixed with *Thalassia*, presumably in relatively small quantity. Here again, the presumption may be erroneous as no quantitative data are available. A fifth species, *Halophila baillonis*, is known only from deeper water north of Tampa Bay and apparently does not occur in the beds. It forms, presumably, small patches at depths of eight to thirty meters but apparently no one has studied it in the Gulf of Mexico..

A sixth species, *Ruppia maritima* L., is present off river months, especially in beds of *Halodule wrightii*, but also mixed with *Thalassia*. It is not a true seagrass as its normal habitat is fresh water; however, it extends into the sea in places as it can tolerate considerable salinity.

The seagrass beds between Tarpon Springs and Port St. Joe are probably the most important community of the inner shelf in basic productivity. Apparently they far exceed the basic productivity of phytoplankton in the area they occupy, perhaps several thousand square miles of inner shelf

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bottom. Their ecological importance, however, is not only their basic productivity: they also provide what may be an essential environment for many species of invertebrates and fishes, including some of economic value in both sport and commercial fisheries.

Our lack of knowledge of these seagrass beds is appalling, especially in view of the impending oil production activity that will soon begin near their habitat. It was only as recently as 1956 that the writer (Humm 1956) reported the essentially continuous occurrence of these seagrasses around the coast of the northern Gulf of Mexico, (except where inhibited by river discharge) in response to the statement in _Gulf of Mexico, Its Origin, Waters and Marine Life_, page 194, (Thorne, in Galtsoff (Editor) 1954) "The apparent rarity of marine spermatophytes except _Ruppia_ on the northern Gulf coast between Bay County, Florida, and Aransas County, Texas, may be significant."

We should determine if currently available aerial photographs provide the optimum through-water visibility and whether they will show the outer, deepest margin of the seagrass beds. If available photographs are not adequate, we should undertake new aerial photographing at the earliest possible moment, to be followed by ground-truth studies and sampling in order to provide data on biomass, species composition, and density. Some of this work must be done by means of underwater vehicles. Growth rates of the seagrasses should be determined at all seasons, and methods of reproduction studied. _Thalassia_, for example, produces seeds in abundance among the Florida Keys and the Bahamas, but apparently does not produce seeds in the northern Gulf.

We should determine the hydrocarbon and heavy metal content of seagrass leaves, beginning immediately in order that data will be available to permit detection of any significant increases. A portion of the seagrass leaves enters the marine food chain leading to commercial fisheries species.

We should determine the significance of these vast seagrass beds as nursery grounds, and we should determine the abundance and significance of the algal epiphytes that occur on the leaves, as these plants contribute a great deal to basic productivity of the area and also serve as food for animals.

It is of major importance that studies of the seagrass beds nearest the presently designated drilling sites begin at once.

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Benthic Plants in the Eastern Gulf of Mexico

Sylvia A. Earle
Los Angeles County Museum
Los Angeles, California

The submarine meadows of seagrasses and algae in the eastern Gulf of Mexico represent one of Florida's greatest assets, and also one of her best kept secrets. Few citizens know of their existence, and of those who do, most take them for granted. They therefore may be lost or damaged inadvertently before their true significance is known. Like the seemingly endless forests that greeted early settlers in North America, the submarine meadows bordering Florida's west coast greet us now--a nearly pristine, primitive wilderness. The greatest value of this wilderness is not in the potential of a harvestable crop, nor because of spectacular beauty. Rather, the significance is more subtle. Much remains to be learned before the true significance of the benthic vegetation can be evaluated, but some aspects are obvious based on existing knowledge. Biologically, they are important because they supply two basic needs for numerous marine animals in the Gulf of Mexico: food and shelter.

Primary productivity in the ocean is frequently evaluated only in terms of phytoplankton, a valid approach in areas where few benthic plants occur, but not valid in the eastern Gulf of Mexico where the continental shelf is broad and shallow, providing a vast area appropriate for attached vegetation. Few studies have been made on the productivity of benthic plants in the Gulf of Mexico (Earle, 1972a), but enough has been done to demonstrate that the role of benthic seagrasses and algae is considerable.

Direct consumers of benthic plants include numerous invertebrates such as polychaete worms, molluscs, sea urchins, sea turtles, and a great number of tropical fishes. Randall (1967) examined 212 species of West Indian fishes, most of which occur in the Gulf of Mexico, and found 59 species in 16 families that had eaten a total of 125 species of benthic plants. Three families were found to be almost entirely herbivorous (Scaridae, Kyphosidae, Acanthuridae). When plants die and disintegrate, additional hosts of detritus-feeding invertebrates are provided with food. The basic material produced by benthic plants fans out through food chains as herbivores are eaten by carnivores, and consumers become consumed. Humans are a part of this chain with an interest economically and gastronomically in omnivores such as shrimp and carnivores including lobsters, snappers, groupers, and numerous other commercial and sport fishes.

Benthic plants are also significant, biologically, because they provide substrate for epiphytic algae (Humm, 1964) and sessile invertebrates, and shelter for numerous mobile animals.

The geological significance of benthic plants also warrants careful evaluation. Certain algae, such as _Halimeda_, _Udotea_, _Rhipocephalus_,

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Corallina, Jania, and Lithothamnion, precipitate calcium carbonate from sea water. These plants contribute to the formation of calcereous rubble as well as fine sediments, and some species may make up much of the substance of "coral" reefs.

The possible effects of petroleum on benthic plants may be considered in two categories, chemical and physical.

Chemical Effects. With extensive offshore drilling in the eastern Gulf of Mexico, it is expected that additional hydrocarbons will be released into the marine environment. It is important to know what effects these hydrocarbons will have on marine plants, but in fact, this information is not known. We should find out what will occur with changes in the hydrocarbon content of these plants and what will be the significance of these changes on herbivores, the animals that eat herbivores, and ultimately, on human consumers.

Physical Effects. The physical impact of oil spills on submarine meadows, salt marshes, and mangroves should be considered and methods to cope with such spills in shallow water should be developed before they happen. Perhaps plants will regenerate through a blanket of oil; perhaps they will not. Such information should be known. If muds used in drilling are released directly into the surrounding water, on what will they land? Will it reduce the level of subsurface solar light? If so, how much? To what effect? As platforms are installed, what disturbance will result? Will the effects of extensive offshore construction be long-range or ephemeral? Will the construction of numerous offshore platforms have certain benefits for marine life comparable to artificial reefs, that will offset construction damage? Such questions should be answered with all possible speed.

To evaluate the changes that may occur in the eastern Gulf of Mexico because of proposed drilling and platform construction, it is necessary to have baseline information for comparison. Much is known about the benthic plants in the Gulf of Mexico, yet much remains to be learned about their distribution, ecology, and basic biology.

More than 350 species of algae are known to occur in the eastern Gulf including 97 Chlorophyta, 52 Phaeophyta, 30 Cyanophyta, and 6 species of seagrasses (Earle, 1972a). Some, such as the deep-water green alga, Anadyomene menziezii (Humm, 1957) may occur to the limits of the continental shelf, although most benthic algae occur in less than 30m depth, and most sea grasses in less than 10m. Because the continental shelf is broad, with a gradual seaward slope, the area where attached vegetation may occur is vast.

Many think the term "estuary" is appropriate only for semi-enclosed areas at river mouths, but there is some justification for regarding the northeastern Gulf of Mexico from Apalachee Bay to the vicinity of Tampa Bay as one gigantic estuary. Freshwater runoff from numerous rivers and offshore freshwater springs reduces salinity over wide areas. Along the shore, an intricate network of submarine meadows and salt marshes merge. Extensive beds of attached Sargassum thrive at river mouths, and may occur several miles offshore. For example, six miles offshore from the mouth of the Homasassa River Sargassum has been observed growing on limestone in less than 2m depth.

To properly assess new environmental influences, it is necessary to be aware of existing factors that affect the occurrence of growth of plants. Light, temperature, salinity, substrate, nutrients, and grazers are among the known factors affecting marine plants. Temperature has the most obvious impact on broad patterns of algal distribution. In inshore waters in the Gulf of Mexico, temperatures may range from 0°C to more than 32°C (Earle, 1969), and a pronounced seasonal change occurs in the algae, with temperate species prominent during the winter months, and tropical species apparent during warm months. Offshore, temperatures fluctuate less and a year-around tropical flora is maintained even in the northern Gulf.

What plants occur where is also determined by the kind of substrate present. Some require a hard substrate, such as rock (or the pilings of a platform); others, including seagrasses and several species of green algae, most commonly grow in soft substrates, and are important as stabilizer. Still others are normally found growing as epiphytes on seagrass or other algae.

The impact of grazing fishes and invertebrates on the distribution and composition of the vegetation in a given area has recently been evaluated in several tropical locations (Randall, 1961; 1965; Earle, 1972b) but no concentrated study has yet been made in the eastern Gulf. Herbivores occur in abundance, and, by inference from studies elsewhere, undoubtedly affect the distribution of plants in certain areas, particularly where grazers are concentrated.

Recommendations

Although there is some basic information about the benthic plants in the Gulf of Mexico, it is necessary to know about the vegetation in relation to the proposed offshore wells. First, there must be additional baseline information. This should include studies to further determine the seasonal behavior of benthic plants, expecially in offshore areas, particularly in the vicinity of the proposed wells. These data then can be compared with seasonal behavior after the wells are active. To obtain information about the overall occurrence of attached plants in the eastern Gulf, there should be extensive aerial photography supplemented by diving at selected sites to verify and amplify the aerial data. Once the extent of the vegetation is documented (including seasonal changes), it will be possible for the first time to obtain a meaningful evaluation of the productivity of benthic plants in the eastern Gulf.

Information on hydrocarbons, and the changes through time, should be recorded. Reactions of the plants to these changes should be evaluated. Physical alterations in the environment should be monitored and the impact assessed.

To implement these studies, stations should be established to gather physical, chemical, and geological data, and to study selected species on a continuing basis. Permanent stations for long-term monitoring are essential for meaningful evaluations. When possible, there should be simultaneous collecting and observations of plants and animals at these stations, coordinated with chemical, geological, and physical oceanographic work. To cover wide areas for observation and photography, submersibles can be used to good advantage. Ultimately, offshore underwater laboratories, such as the simple but highly effective HYDROLAB might be established in the vicinity of certain wells to gather intensive environmental data. The methods for environmental assessment are available and the need is obvious. Now comes the work.

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Benthic Invertebrate Communities of the Eastern Gulf of Mexico*

William G. Lyons
Florida Department of Natural Resources
Marine Research Laboratory
St. Petersburg, Florida

Sneed B. Collard
University of West Florida
Pensacola, Florida

Although a number of studies of benthic invertebrate groups, or communities of such organisms, have been published from various areas of the Eastern Gulf of Mexico, few attempts have been made to pull together information necessary to understand distributions and relative differences of these communities. The first major attempt was "Gulf of Mexico, its origin, waters, and marine life" (Galtsoff, 1954). While it contains some very worthwhile studies, in retrospect many of its papers have proven highly inadequate. Whatever its merits, it was an up-to-date summary of existing knowledge when published.

After this collection of papers appeared, nearly twenty years passed before the State University System Institute of Oceanography (SUSIO) called together a group of specialists to produce a synthesis of opinion regarding the location and composition of dissimilar hydrobiological zones of the Eastern Gulf. From these meetings have come at least three very impressive compendia integrating existing knowledge of physical and chemical oceanography, geology, climatology, and biology to bring us an up-to-date "Summary of Knowledge" of these various zones. It is our opinion that, if this were a competitive endeavor, the biologists lost.

The task of these biologists was to pull together existing information, primarily from published literature, to produce this summary. For some, information was both available and comparable, and is reflected in their reports. The benthic invertebrate report for inshore, estuarine areas is far better than comparable information of 20 years ago. However, accounts of offshore shelf communities are nowhere as definitive, because much of the needed information has not been analyzed or published.

This does not mean that collecting trips have not been conducted nor observations made. Though certainly not to the degree of accessible inshore locales, offshore areas are being and have been studied, both by conventional collecting techniques and, in accessible areas, by scuba. Despite several thousand such collections, we have yet to see published a species list of the collective contents of a single dredge haul, much less attempts to pull together information from many such collections. The few published scuba observations are not adequate to define these invertebrate communities. Sponges and corals have long been acknowledged as very important basic constituents of allegedly highly diverse Eastern Gulf Shelf communities, but no serious attempt has been made to adequately define composition or dynamics of such communities.

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*Contribution No. 233, FDNR/MRL

This treatment of benthic invertebrates of the Eastern Gulf of Mexico follows that of Collard and D'Asaro (1973), in that a community approach is used to divide the region into recognizable biotopes defined by change in species composition. However, some divisions differ from those of the previous authors. These are related principally to subdivisions of the shelf fauna resulting from more than eight years of observations by one of us (WGL) on materials collected during the Hourglass Project and other West Florida Shelf programs.

Biological and geological factors dictate that the Eastern Gulf Shelf area be divided into two subregions, the Mississippi-Alabama Shelf extending from the eastern Mississippi Delta to Cape San Blas, and the West Florida Shelf extending from Cape San Blas southward to the Florida Keys. Subdivisions of these subregions, except estuarine and slope faunas, will be discussed separately. Physical and biotic characters serving to subdivide the subregions are hereafter discussed beginning at the land-water interface and proceeding ever deeper to the base of the continental slope. Collard and D'Asaro have summarized factors controlling composition of benthic invertebrate communities of the region. Briefly, these amount to temperature, salinity, substrate, wave action, and nutrients. Each factor is very important, and it is differences in these factors that create different communities.

Estuaries

The single category "Estuary" contains much of the first four of Collard and D'Asaro, i. e., "Low Salinity Communities," "Oyster Reef Communities," "Oyster, Mangrove and Hard Substrate Communities," and "Bays, Channels, and Sounds." The authors also recognized various subdivisions within most categories, based on salinity, temperature, vegetation, and substrate.

It is sufficient here to state that these areas, located along most of the Eastern Gulf coast, are characterized by salinity gradients generally ranging from 0 to ca. 34 $^{o}/oo$, with broad fluctuations caused by rainfall (or lack thereof), tides, and other factors. Temperature fluctuations are usually much greater than in other marine environments. Substrates may vary considerably, both within a single estuary and between estuaries. Nutrient values are generally higher than in other marine environments.

Of these factors, perhaps temperature and salinity fluctuation and high nutrient values are most characteristic in separating estuaries from other marine communities. However, substrate and vegetation are just as important in determining composition of communities. All factors are, to some degree, interrelated.

A remarkably high number of benthic invertebrates are adapted to exist under the rigorous conditions of Eastern Gulf estuaries. Cooley (ms) has listed more than 500 species in the Pensacola Bay area, Menzel (1971) has noted at least that many estuarine species in the Alligator Harbor area, and certainly more than 600 species occur in the Tampa Bay estuarine system (Taylor, 1971; Hall and Lyons, ms; other unpublished data). Much of the Florida West Coast may be considered "ecotonal" between the temperate Carolinian and tropical Caribbean zoogeographic provinces. Such areas, generally high in species diversity, result from occurrence of hardier types from each province. Constituents of both provinces occur throughout the area, although naturally more species of temperate affinity are found in the north and more of tropical origin occur in the south. There is also a small Gulf endemic element. However, most estuarine species are not easily assignable to any of these categories. Instead, as noted by Lyons et al. (1971), they belong to a broadly ranging, eurytolerant group found at least from North Carolina to the southern Caribbean. Broadly fluctuating salinities and, to an extent, temperatures, are characteristic of habitats through much of their range. They are the basic elements of most estuaries, while the "provincials" and endemics, more sensitive species, serve to characterize individual estuarine differences. These subtleties result in "northern" and "southern" communities.

A. Low Salinity Communities (Marshes and Deltas; Marshes and Mangrove Swamps): Each of these is characterized by low salinity and organically rich sediments. Mangrove communities are dominant in the south but entirely absent in the north, primarily due to low temperature intolerance. Spartina-Juncus marshes occur extensively in the north, but much less so in the far south. Both occur south of Cedar Key, but with mangroves increasingly dominant to the south.

B. Oyster Reef-Hard Substrate Communities: This is the major sessile invertebrate community of Eastern Gulf estuaries. It is based upon Crassostrea virginica throughout the region, but widely diverse temperatures and salinities dictate different species associations at different localities.

C. Bays, Channels, Sounds: Though still characterized by broadly fluctuating salinities and temperatures, overall mean values may be higher than in the previously mentioned areas. These factors are still important in determining local species composition, but substrate, vegetation, and depth are also major factors.

Substrates may vary from muds, terrigenous sands, and mixtures thereof in the north to vegetable debris and calcareous sands in the far south. Terrigenous sands are not important south of Cape Romano. Quartz sandshell mixtures dominate most of west Florida, but muds become important west of the Apalachee Bay area.

Pure or mixed stands of seagrasses occur in estuaries throughout the region. Species include Thalassia, Syringodium, Halodule, and Ruppia. Two species of Halophila are less common. Most of these grasses reach their greatest densities in estuaries, but in this area are generally limited to depths less than 2 m because of poor light penetration. This leaves greater estuarine depths as non-vegetated substrate inhabited by species not tied to a "grassbed" existence.

Aside from oyster reefs and grassbeds for epiphytes, most estuarine substrate may be characterized as "soft." Because "hard" substrate is rare to nonexistent in the Carolinian Province, there are few "hard" substrate Carolinian species. It seems, therefore, that except for certain grassbed or oyster reef species, Eastern Gulf estuaries have been surrendered to "soft bottom" Carolinian species by default. Exceptions may occur where introduced objects such as pilings or jetties provide setting space for Caribbean species, but even these objects are usually occupied by species from oyster reef or grass communities.

Generally, estuaries are herein considered as coastal invaginations, often separated from the Gulf of Mexico by barrier islands. However, certain shallow offshore areas of low wave energy display typical estuarine characteristics. These include extensive shorelines from Apalachee Bay to the Anclote Keys and, further south, the Ten Thousand Islands area from Cape Romano to Cape Sable. These seem to represent estuaries intergrading directly into shallow shelf communities.

West Florida Shelf

The following delineations (Figure 1) are based upon observed faunal variation in more than 700 dredge and trawl tows from the Hourglass program, supplemented by many comparable collections and some scuba observation in other areas of the shelf. The degree of faunal change is the criterion used for suggesting separations. Obviously, each zone intergrades into its neighbors without sharply defined boundaries, and areas of intergradation are difficult to categorize. Nevertheless, central areas of these zones seem distinctive. Geological and hydrological features coincident with the zones are suggested as basic factors of community composition. Suggested depths for each zone are mean estimates; these depth limits may vary somewhat in response to geologic and hydrographic variation.

1. Shoreward Zone (0-10m): This zone is defined as the area extending from the land-water interface to depths of approximately 10 m. The latter is the mean depth where rocky outcrops become important substrate elements along much of the Florida west coast. Salinities fluctuate several parts per thousand in response to runoff from nearby rivers and bays. Temperature variations are nearly as severe as in adjacent estuaries. Nutrients are generally quite high. Four subdivisions are proposed for the shoreward zone.

A. Ten Thousand Islands: Extending northward from Cape Sable to Cape Romano, this area is characterized by grassbeds and scattered sand bottom blending the mangrove estuary smoothly into the offshore rocky communities. Many shallow water tropical species from the Keys occur here, especially in grassy portions, but many temperate species are also common, especially in sand communities. Beaches are scarce.

B. Coastal Barrier Islands: Moderate wave energy beaches of quartz sand and shell fragments are the dominant shoreward feature of this zone which extends northward to Anclote Key. Bottom composition is also largely of these materials, with little hard substrate except dead shells of large mollusks. Seagrasses are scarce to absent. The quartz-shell sediments actually extend far to sea off Tampa Bay and the Charlotte Harbor area. In the latter area, influence of these sediments is quite strong in the next seaward zone, and possibly even beyond. Large temperate mollusks and echinoderms are characteristic faunal elements. Species diversity is generally lower than in adjacent estuaries or offshore areas.

C. Big Bend Area: This may be best defined as a huge, seagoing estuary extending from near Anclote Key to the vicinity of Alligator Harbor. Oyster reefs are common parallel to the shore, and vast beds of seagrasses are characteristic of the area. A thin veneer of quartz sand and organic debris overlies the limestone plateau of the Ocala-Middle Ground Arch. Occasional limestone outcrops protrude through this veneer to provide hard substrate. Species composition is predominantly the same found in estuarine seagrass or oyster reef communities. The shoreline receives only low energy waves.

D. Cape San Blas Area: Moderate wave energy quartz sand beaches are characteristic of the area from Alligator Harbor, and comparably composed sediments extend some distance offshore. The fauna is similar to that of the Coastal Barrier Islands area in that it is predominantly a temperate sand community. Most common species are represented in both areas.

2. Shallow Shelf (10-30 m): This is the first major zone of tropical species intrusion into the Eastern Gulf. Rock substrate allows establishment of many scleractinian, alcyonarian, molluscan, crustacean, and other invertebrate species common in shallower waters in the Florida Keys. Sand dwellers are represented by some species from more inshore waters but with many tropical species as well. Sediments are still largely of quartz sands, with increasing percentages of biogenically derived carbonates seaward. Overlying green, relatively turbid, coastal waters are usually well mixed, but cooler bottom waters are often separated by a low thermocline, especially during warmer months.

3. Middle Shelf I (30-60 m): Two apparent physical characters separating this zone from the shallow shelf are widespread carbonate sediments and an overlying mass of blue, offshore water. The intersection of this water mass with coastal green water is usually very visible in depths of about 30 m. Widespread rock outcrops are lower in the central and southern portions than on the Florida Middle Grounds, where they may rise 12 m above the surrounding bottom. Loggerhead sponges, corals, and tropical algae form communities supporting many other tropical species. Appearance of many tropical sand dwellers is probably due to largely carbonate sediments. Communities are highly diverse, containing many more species

than found in inshore zones.

4. Middle Shelf II (60-140 m): Few rock outcrops are found in this zone. Sediments are almost entirely carbonate, being composed of coraline alga (Lithothamnion), bryozoan and molluscan fragments; foraminiferal tests begin to contribute noticeably to sediments. Scattered sponges, bryozoans, ascidians, and alcyonarians attached to small rocks and shells form the dominant sessile epifauna. Many small molluscan and crustacean species are very common. Bottom water temperatures seldom exceed 22°C, are warmest in late fall, and are usually distinctly separated from warmer surface waters except during winter when mixing may occur. This zone receives waters from the Florida Loop Current, and salinities greater than 36.5 °/oo occur seasonally. The fauna is essentially tropical or tropically derived; some data suggest a small number of endemic northeastern Gulf mollusks at these depths.

5. Deep Shelf (140-200 m): It is problematical that a separation exists between 60 and 200 m. Sediments seem generally similar throughout; naturally water temperatures are depressed and little light penetration prevents most algal growth in deeper waters. Species diversity apparently decreases in these greater depths, but many species of the Middle Shelf II zone occur here. Changes in species composition noticeable at about 140 m in both fish and mollusks prompt designation of this depth as the intersection between zones. Pequegnat (1970) noted a number of brachyurans most common in depths corresponding to the deep shelf zone.

Mississippi-Alabama Shelf

The authors have little direct familiarity with this area beyond the estuaries and shoreward zone. A major physical feature influencing community compositions here is proximity to the nearby DeSoto Canyon, with a resultant steeply sloping shelf and nearshore intrusion of oceanic waters to high wave energy beaches. Mississippi Delta sediments are characteristic of the area from Mobile Bay westward.

As on the West Florida Shelf, far more collections have been taken than have been reported; most reports consist of individual species records rather than compendia of collections.

1. Shoreward Zone: Quartz sand is the dominant sediment element to depths of approximately 20 m from Cape San Blas to near Mobile Bay. The fauna is characteristically temperate sand dwellers. Many species common here are uncommon to absent in other Eastern Gulf sand communities. Moreover, many species found elsewhere in the Eastern Gulf attain larger sizes in the zone west of Cape San Blas. Jetties and wrecks provide hard substrate for some tropical species which could not otherwise occur here. Muds become more important near the Mississippi Delta, with correspondent lowering of the number of species present.

2. Deeper Areas: Faunal zone demarcations beyond the shoreward zone are not clear. Rocky outcrops first occur commonly off Panama City and

Destin in about 20 m, but these diminish in number at comparable depths to the west. A highly diminished tropical fauna occurs on these outcrops. A zone of calcareous sediments occurs on deeper parts of the shelf, and even a few limestone reefs are known near the edge of the shelf. Species from these calcareous communities are essentially the same as from others further south, but diversity may be reduced.

As in shallower areas, these sediments merge into sands, muds, and silts from the Mississippi outfall to the westward. Faunal change and species diversity reduction accompany this transition to soft bottom communities.

Slope

Calcareous sands give way to foraminiferal sands and muds in this area where the bottom slopes steeply (200-3200 m) from the shelf to the Gulf floor. Many species are confined to these depths, forming a characteristic slope fauna. Obviously, in so great a depth-span most are not found throughout, but many do exhibit considerable bathymetric range. Species diversity of many groups is markedly lower than for shelf zones, but penaeid and large caridean shrimps and galatheids show their greatest diversity here.

In summary, benthic invertebrates of the Eastern Gulf are a highly diverse group with several dissimilar zones of distribution ranging from the estuaries to the continental slope. Whereas temperature and salinity fluctuations are limiting factors in estuaries, such values become more constant offshore. These narrow ranges of fluctuation are important for the dominantly tropical offshore fauna. Bottom substrates and overlying water masses seem to become more critical offshore. The northern limestone base, best expressed at the Middle Grounds, and the southern quartz sand extensions are contrasting features superimposed upon this basic scheme. However, differences are nowhere near as absolute as might be deduced from the previous geological charts. Scattered limestone communities occur as frequently to the south as do scattered sand communities in the north. Where these communities are found, species compositions are essentially the same within zones.

Many areas are open for investigation of invertebrate communities. However, emphasis should be given to the importance of working up the many collections already made in this region. To repeat some would merely constitute duplication of effort, and some collections, already made but not reported, could not possibly be duplicated before extensive drilling for oil is under way in the Eastern Gulf.

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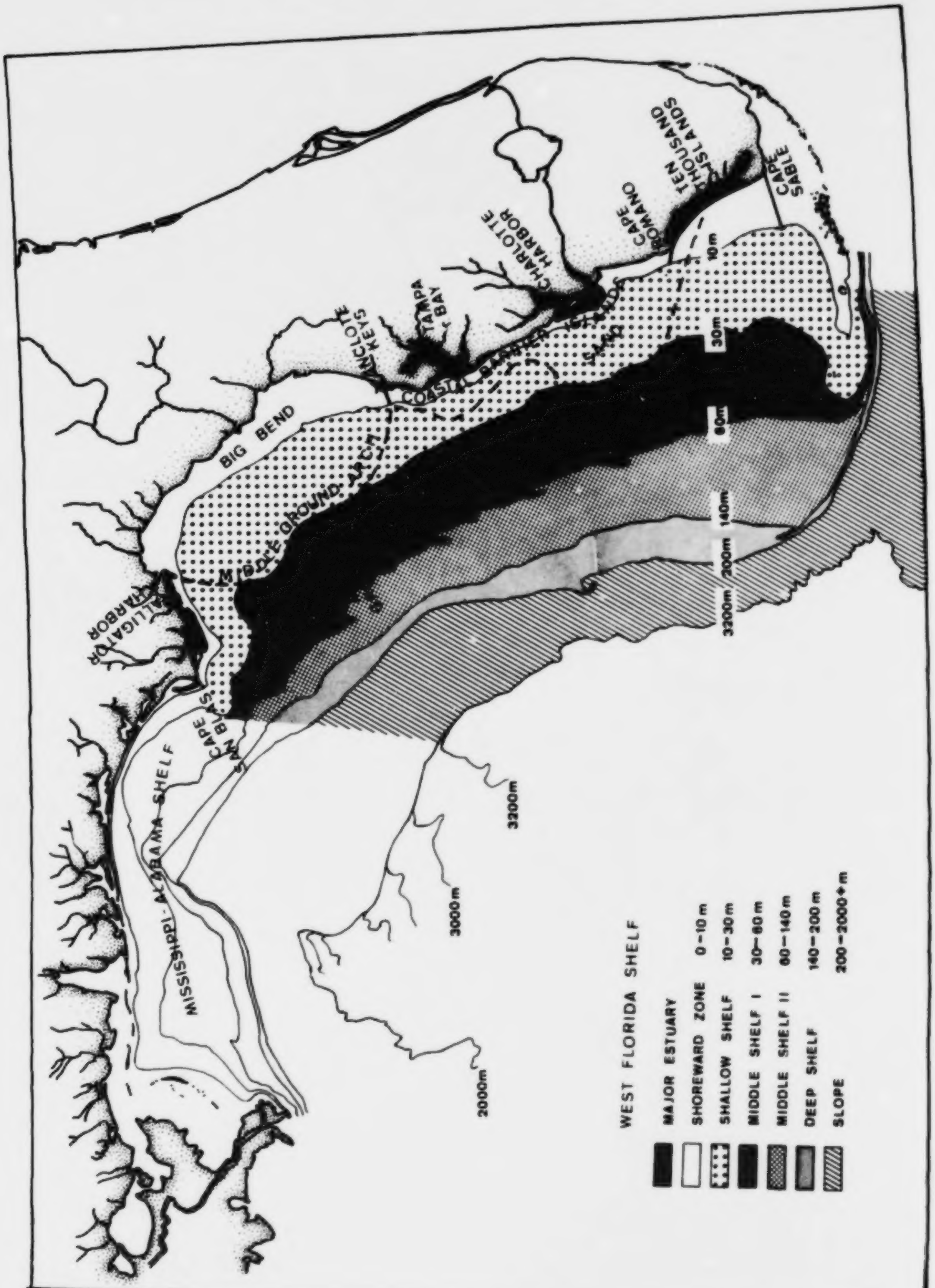
WEST FLORIDA SHELF
MAJOR ESTUARY
SHOREWARD ZONE 0-10 m
SHALLOW SHELF 10-30 m
MIDDLE SHELF I 30-60 m
MIDDLE SHELF II 60-140 m
DEEP SHELF 140-200 m
SLOPE 200-2000+ m
MISSISSIPPI-ALABAMA SHELF
CAPE SAN BLAS
ALLIGATOR HARBOR
BIG BEND
MIDDLE GROUND ARCH
ANCLOTE KEYS
TAMPA BAY
COASTAL BARRIER ISLANDS
SAND
CHARLOTTE HARBOR
CAPE ROMANO
TEN THOUSAND ISLANDS
CAPE SABLE
10m
30m
60m
140m
200m
3200m
2000m
3000m
3200m

FIGURE 1.

Potential Effect of Oil Drilling/Production Activities on the Phytoplankton/Zooplankton in the Eastern Gulf of Mexico

Sayed Z. El-Sayed
Department of Oceanography
Texas A & M University
College Station, Texas

Thomas L. Hopkins
Department of Marine Science
University of South Florida
St. Petersburg, Florida

Karen A. Steidinger
Florida Department of Natural Resources
Marine Research Laboratory
St. Petersburg, Florida

Introduction/Objectives

The problems with which we are primarily concerned are the study of the potential effects of oil drilling and production activities on the environmental quality of the eastern Gulf of Mexico, and the changes in the marine ecosystem of this area brought about by these activities.

Answers to these problems are urgently needed. The agencies charged with the management of these areas need an ecological basis for the adoption of appropriate management strategies.

The specific objectives can be summarized as follows:

1. to establish baseline data for the areas of intensive petroleum operations and to compare them with data from "undisturbed" areas;
2. to compare baseline data from the MAFLA drilling sites with data where drilling/production operations have been going on for many years (e.g. offshore Louisiana);
3. to study changes in the ecosystem in the eastern Gulf of Mexico, and to determine whether such changes are due to natural phenomena, human activities, or petroleum operations;
4. to gain a predictive understanding of the changes in the ecosystem as a result of oil drilling/production operations so that what we learn from the MAFLA experience can be applied elsewhere.

In my talk I will discuss the potential effect of oil drilling/production operations on the marine ecosystem in the eastern Gulf; special

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emphasis will be placed on the effect these oil activities have on the primary producers, i.e. the organisms found at the bottom of the food chain. However, before we do so, it would be well to present a brief summary of our knowledge of primary productivity, phytoplankton, standing crop, species composition of phytoplankton, and nutrient salts in the Gulf of Mexico based on the data collected during the past ten years (1964-73)*.

Of special interest in the proposed phytoplankton investigation are the detailed studies which were carried out by El-Sayed (1967) between June 1964 and May 1966 in the northeastern Gulf of Mexico (Figure 1). During this period, monthly observations of primary productivity, standing crop of phytoplankton, nutrient salts, and hydrographic conditions were made at both Stage I and Stage II, off Panama City, Florida and 20 additional stations in the northeastern Gulf. The value of these data stems from the fact that they can be utilized as 'baseline data' where environmental perturbations have been minimal.

Also of special relevance and significance to the proposed MAFLA (Mississippi-Alabama-Florida) investigations are the Offshore Ecology Investigations (OEI) which were carried out off the Louisiana coast (Figure 1). These investigations, which began in 1972, were to study the effect of the oil drilling/production on the biota, water chemistry, and bottom sediments in the vicinity of the oil platforms. Here again, the data collected during the O.E.I. can be an invaluable source of information for comparison with the data to be collected at the proposed MAFLA sites (A, B, C, and D in Figure 1).

Based on the data collected by the speaker in the northeastern and eastern Gulf of Mexico an attempt is made to summarize the state of knowledge of phytoplankton/zooplankton investigations off the west coast of Florida (Table 1), and in the northeastern Gulf (Table 2). It is clear from both tables that there are still enormous gaps in our knowledge with regard to the biology, general ecology, seasonal and geographic distribution, metabolism, turnover rates of the phytoplankton/zooplankton organisms, and the relationship of the hydrographic conditions on the distribution and abundance of these organisms -- gaps which one would hope will be filled in before too long.

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*The speaker used a series of slides in presenting this summary. These data have recently been published by the American Geographical Society (Serial Atlas of the Marine Environment, Folio 22: Chemistry, Primary Productivity, and Benthic Algae of the Gulf of Mexico, 1972. An excellent review of the phytoplankton of the eastern Gulf of Mexico was recently provided by Ms. Karen Steidinger (1974) -- SZE).

Program for Studying Ecosystem Dynamics of the Eastern Gulf of Mexico

In developing a program to study the potential effect of oil drilling/production activities on the biota of the eastern Gulf, we should be guided by three important principles:

1. The ecosystem approach should be adopted (see below).
2. The collective research effort should be directed toward an understanding of the oil drilling/production operations on the 'state of health' of the ecosystem.
3. The program should be based on well-coordinated, synoptic, interdisciplinary investigations repeated at intervals and over sufficiently long periods of time.

Within the framework of these guidelines, there are geographic and temporal considerations which should be taken into account.

Geographic Factors

a. The program should emphasize investigations in areas of potential petroleum production as well as non-producing areas in order that baseline data in both regions be compared. In a study, the objective of which is to assess the effect of oil drilling/production, it is of paramount importance to compare the data collected at the drilling/production sites with those in regions with minimal environmental perturbations.

b. The program should include such diverse regimes as estuaries, nearshore and offshore sites.

c. The program should include studies made along transects between the selected sites.

Temporal Factors

a. The program should cover a period of two years; this period is to be regarded as the minimum time interval in which meaningful results can be obtained. Naturally, longer periods are preferred in order to study the effect of natural phenomena on the ecosystem.

b. Hurricanes, storms, unusual river discharges, etc., may overshadow even the most catastrophic impact of man's activities; the effect of the unusually high flood of the Mississippi River in Spring 1973 is a case in point (El-Sayed, unpublished).

c. Each sampling site should be visited once a month, or a minimum of two visits per season, in order to study the seasonal variations of the physical/chemical/biological parameters.

Elements of the Structure and Function of the Ecosystem

As was pointed out above, the ecosystem approach should be strongly endorsed. Listed below are the elements of the structure and function of that ecosystem which need to be studied.

The Physical/Chemical Milieu

a. Solar radiation/spectral quality of light in water; temperature; salinity; oxygen; surface and bottom currents (direction and velocity); total suspended particulate matter (turbidity), etc.

b. Inorganic and organic nutrients; vitamins; selected toxic metals; trace elements

The Biological Setting

a. Benthic algae, seagrasses, mangroves and phytobenthos

b. Phytoplankton

c. Bacteria, marine fungi

d. Zooplankton

e. Benthic invertebrates

f. Fishes/mammals/birds

Ecosystem Function

a. Rate of carbon fixation (by primary producers)

b. Rates of turnover

c. Metabolic studies (microbial respiration, crustacean metabolism, etc.)

d. Transfer of energy through the ecosystem

Objectives for the Study of Primary Productivity in the Eastern Gulf of Mexico

1. To measure primary productivity at the designated drilling sites (rate of photosynthesis is a sensitive index of the effects of environmental changes on phytoplankton)

2. To estimate the standing crop and biomass of the phytoplankton

3. To determine species composition, population density, and diversity indices of phytoplankters

4. To determine seasonal (or monthly) variations in the productivity parameters

5. To determine nutrient chemistry (PO_4, SiO_3, NO_2 and NH_4); particulate and dissolved organic C, N and P; vitamin B_{12}, biotin and thiamine; and their effect on rates of primary production

6. To correlate the productivity data above with depths of pycnocline, stability of water column, areas of upwelling, etc.

7. To determine possible use of phytoplankton species as 'indicators' of changes in their environment

The proposed phytoplankton and zooplankton investigations outlined above are but one facet of well-integrated biological, chemical and physical programs which one hopes to see developed for the MAFLA investigations. It is critical that the biological system be approached as a single functional unit. The synthesis of the above-mentioned studies, together with the contributions of allied and related studies, should provide us with a comprehensive picture of the primary and secondary producers in the eastern Gulf, and of the factors which regulate production of these two important trophic levels.

Table 1

Summary of State of Knowledge of Phytoplankton/Zooplankton
Investigations off West Coast of Florida

	Excellent	Good	Fair	Poor	Remarks/Needs
Solar Radiation/ Light Penetration				X	Badly needed for primary productivity studies.
Phytoplankton Standing Crop			X		Need for more geographical and depth studies.
Primary Production			X		
Nanoplankton				X	Significance in primary productivity should be assessed.
Diatoms (Species Composition)		X			Endemic vs 'visitors' (Caribbean) should be determined.
Dinoflagellates (Species Composition)		X			
Seasonal Studies				X	Need to study seasonal succession; seasonal variations in productivity parameters and nutrients.
Inorganic Nutrients			X		Rates of uptake and regeneration of these nutrients are totally lacking.
P.O.C. and D.O.C.				X	
Vitamins and Trace Elements				X	
Relation to Hydrography				X	Future studies should emphasize influence of Loop Current, River Discharge, etc.
Phytoplankton/Zooplankton Relationship				X	An almost untouched field.
Zooplankton Standing Crop				X	Badly needed data
Species Composition/ diversity			X		
Metabolic Studies, Estimation of Secondary Production				X	

Table 2

Summary of State of Knowledge of Phytoplankton/Zooplankton Investigations in Northeastern Gulf of Mexico

	Excellent	Good	Fair	Poor	Remarks/Needs
Solar Radiation/ Light Penetration			X		
Phytoplankton Standing Crop	X				Data on hand can be used as baseline data.
Primary Production		X			
Nanoplankton				X	Significance in productivity should be assessed.
Diatoms (Species Composition)		X			
Dinoflagellates (Species Composition)		X			
Seasonal Studies		X			Monthly observations available between May 1964-April 1966.
Inorganic Nutrients		X			
P.O.C. and D.O.C. Vitamins and Trace Elements				X	
Relation to Hydrography			X		Effect of Loop Current, Miss. discharge should be studied.
Phytoplankton/ zooplankton Relationship				X	Feeding selectivity and contributions of grazers to nutrient regeneration should be studied.
Zooplankton Standing Crop				X	Badly needed data.
Species Composition/ Diversity				X	
Metabolic Studies, Estimation of Secondary Production				X	

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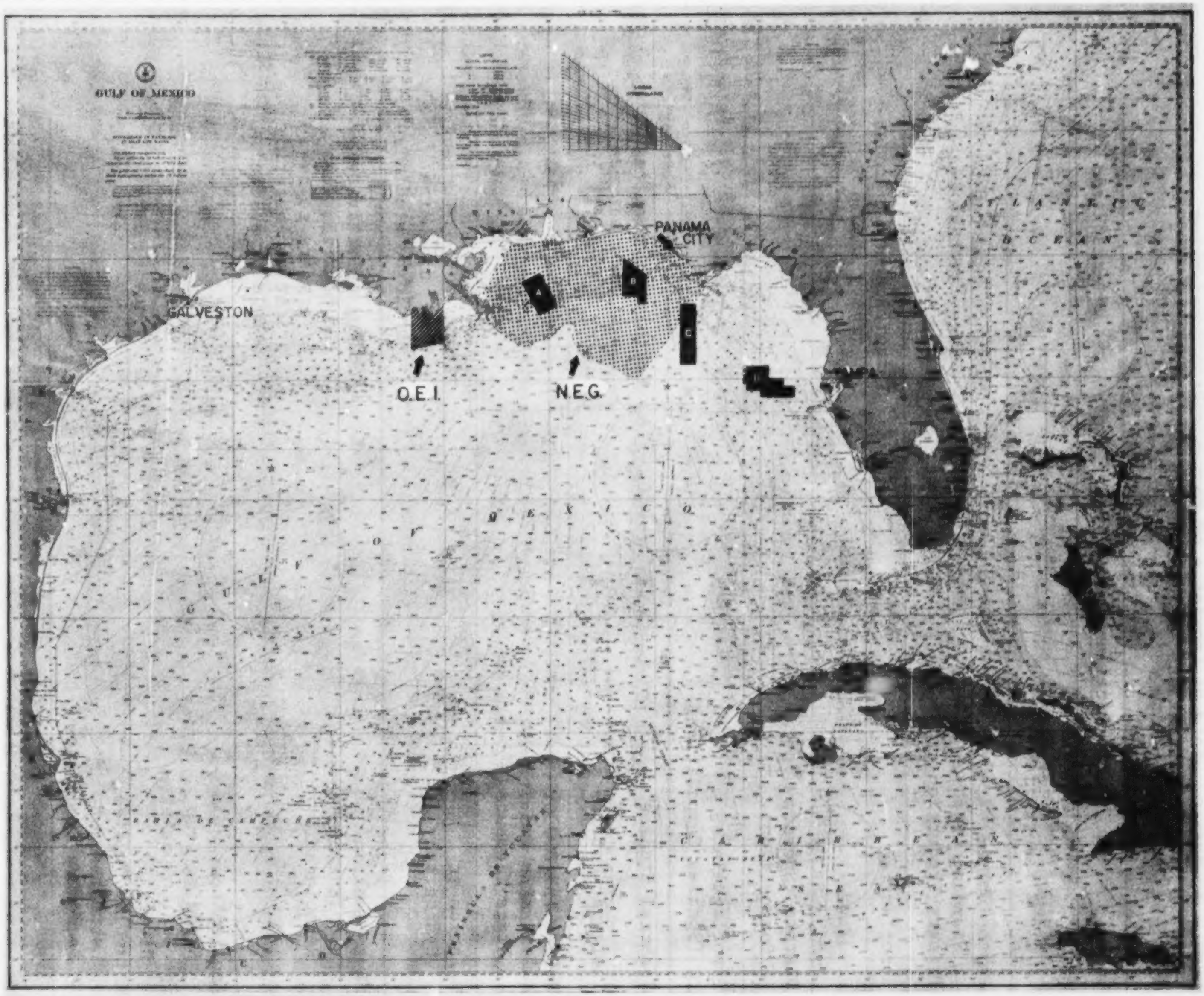
GULF OF MEXICO
GALVESTON
PANAMA CITY
A
B
C
D
O.E.I.
N.E.G.
ATLANTIC OCEAN
GULF OF MEXICO
CARIBBEAN SEA

FIGURE 1. Position of Research Activities Conducted in the Offshore Ecology Investigations (O.E.I.) Regions; Northeastern Gulf (NEG), in Relation to the MAFLA Leased Sites (A, B, C & D).

Biological Indicators of Oceanographic Phenomena*

Herbert M. Austin
New York Ocean Science Laboratory
Montauk, New York

Introduction

The basic analytic tools of the physical oceanographer during the past 50 years have been the measurement of the spatial characteristics of density fields in the ocean for computing relative current velocities, and the use of Helland-Hansen's T-S diagram for characterizing water masses; however it has become apparent that a water mass, as defined by these techniques, may also be a unique ecotope.

Many forms of plankton have been shown to be useful water mass indicators in specific circumstances (Pierce, 1952; McGowan, 1960; Jones, 1968; and Austin, 1971). Most studies of this nature have been completed at the mega-scale level, that is, across major oceanic fronts such as the Antarctic and Arctic Convergence Zones. The application of bio-indicators to delineate more sensitive elements within a given current system has only recently been developed. Boltovskoy (1968) has found two distinct surface foraminiferal assemblages off the coast of Brazil. The measured physical properties of the area were nearly homogenous. He suggested that the micro-organisms were more sensitive to the finite variations in the sea than man's most advanced oceanographic instruments.

Sverdrup, Johnson and Fleming (1942) proposed several criteria for selecting an organism for use as an indicator of oceanographic conditions. These conditions include:

1. The need for accurate identification of all species, subspecies, and (author's addition) environmentally induced morphologic variations.
2. Knowledge of geographic (and environmental) range of each species.
3. Time and depth of reproduction and morphological stages during life cycle of each species.
4. Knowledge of the extent to which a species may extend its normal range by vertical migration.

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*Contribution No. 25, New York Ocean Science Laboratory

5. Distinction should be made between animals from an outside source and animals which develop within localized areas when conditions approximate those of the outside area.

6. Animals coming from a common area are more valuable than strays.

To these, Boltovskoy (1965) has added:

7. There should be a sufficient number so as to offer the possibility of using statistical methods.

In addition to those listed above, Myers (1967) included:

8. Organisms should be of sufficient size to facilitate rapid handling and identification.

9. Populations should be in sufficient concentrations to assure capture within the optional geographic range.

Certainly these criteria should be considered, where possible, when one is considering indicator organisms for baseline OCS studies on the West Florida Shelf. The basic criteria apply, whether one is investigating natural oceanic phenomena or perturbations such as oil spills. For the purpose of this report (and conference/workshops) we are confining ourselves to the eastern Gulf of Mexico--not the geographic eastern Gulf, but the oceanographic eastern Gulf.

In this paper specific examples of biological indicators of physical or chemical oceanographic phenomena will be presented; they will be limited however to pelagic indicators. Benthic indicators of substrate type, overlying water masses, or tidal regimen are not considered here although they have been demonstrated to be excellent indicators of climatic conditions.

The pelagic indicators are dynamic and four dimentional (spatial = x, y axes; vertical = z axis; and temporal = t). An entire food web or ecotope can be transported hundreds of miles in days.

Discussion

Caribbean waters: Past investigators have recognized the presence of Caribbean waters in the Gulf of Mexico by the distribution of temperature and salinity. Stakiv (1968) has demonstrated that the surface component of the Caribbean-derived Eastern Gulf Loop Current (Nowlin and McClellen, 1967) can be delineated by the distribution of sea-surface temperatures. This was true during the May 1970 EGMEX-70-I cruise series at which time the surface velocity core could be defined by the area between the 25° and 27°C isotherm (Figure 1).

It would hold then, that the water of shortest time away from the Caribbean would be found in the velocity core, and that here one would expect to find its Caribbean components. Jones (1964, 1966), from an analysis of Caribbean Foraminifera, found that the dominant species was *Globigerinoides trilobus*, and indeed, *G. trilobus* was found in greatest concentrations in the region of the geostrophic velocity core (Figure 2) (Austin, 1971).

The significance of this is that the presence of substantial numbers of *G. trilobus* ($> 500/1000M^3$) indicates that the water is of recent Caribbean origin.

Regions of Upwelling: The active transport of deep layer waters to the surface can result in the passive transport of deep water species or forms of plankton into the surface layers. Vertical transport is generally slow enough so as to permit these forms to migrate vertically, remaining in their optional strata; some taxa, however, either cannot (Foraminifera and phytoplankton) or do not (Chaetognatha and Pteropoda) so migrate.

The tropical Foraminifera species *Globigerinoides ruber* occurs in two forms: a *pink*, or warm water form; and a *white*, or colder water form (Bé, 1959). The vertical distribution of these two forms, studied in the Caribbean by Jones (1964, 1966), has shown a depth differentiation between *pink* and *white* forms with *pink* predominating in the surface waters and *white* in the deeper waters. The normal *white* distribution in the Loop Current during May is 40-100m (Austin, 1971) and during summer below 100m (Williams, 1972).

A deformed form, *G. ruber pyramidalis*, has also been reported by Berger (1970). This form is also referred to as a variant or "Kummerform" (monster form). These Kummerforms are only found in areas of oceanographic transition. During May, 1970, Kummerform *pinks* and a predominance of *whites* (>90%) over normal *pinks* were collected along the area of the West Florida Shelf and Campeche Banks where, from examination of the physical data (Austin, 1971, pp. 101-104), upwelling was believed to be occurring.

In this same region an intermediate depth pteropod, *Peracles bispinosa*, normally collected between 150 to 250m, was taken only in the surface waters (Figure 3).

Subtropical Underwater: The Subtropical Underwater is a tongue of high salinity waters (36.60-36.90%) at intermediate depth (80-220m) that enters the Gulf of Mexico through the Yucatan Straits, follows the Loop Current, and exits the Gulf through the Straits of Florida. Through its transit of the Gulf it can be found below and to the right of the velocity core. In addition to its high salinity waters it can be characterized by a paucity of both pteropods (Figure 4) and Foraminifera in waters where the salinities exceed 36.50%.

Entrainment of intermediate (75-150m) western Gulf waters into the Eastern Gulf: During its spring intrusion the Loop Current is generally contained within the eastern Gulf, held there by a "cold ridge" (Leipper, 1970; p. 641) which segregates the waters of the west and east Gulf. In May 1970, during the spring intrusion, isobaths of the depth of the 22°C isotherm were closed, showing the typical Loop configuration. Isobaths of the 18°C isotherm were, however, open to the west; and in the region where a return flow would be expected, concentrations of the foraminifera *Globorotalia crassiformis* (>500/1000M^3), not normally encountered in the eastern Gulf, were collected (Figure 5). Their distribution, coincident with this possible return flow, indicate that indeed waters from the western Gulf were being entrained into the deeper Loop Current.

Advection of pelagic Loop waters onto the West Florida Shelf: Summer conditions on the West Florida Shelf are typified by a stratified water column with warm, low salinity waters of generally inshore origin overlying the cooler, more saline waters of offshore origin. During winter the water is usually isothermal and cooler than the offshore waters, although offshore waters remain more saline (Austin and Jones, 1974).

Williams (1972) has shown that species of pteropods, diagnostic of the offshore Loop Current, can be used to trace pelagic water as it is advected across the shelf. Figure 6 shows the relationship between temperature, salinity, and the percent standing crop of *Limacina trochiformis* during a 24-hour anchored station at 28°31'N, 34°19'W on the Florida Middle Ground during summer conditions. From this, one should be able to trace waters of Loop current origin as they advect and mix well in/over the shelf. In fact, Austin (1971, p. 62) found an "eddy" of *L. trochiformis* in the lower salinity waters near the west Florida coast north of Tampa. This "eddy" undoubtedly represented a "residual" population advected into the nearshore water from the Loop Current. The significance of this is that pelagic water can be traced in/over the shelf and followed even after the temperature and salinity, measured by standard methods, have lost their pelagic identity.

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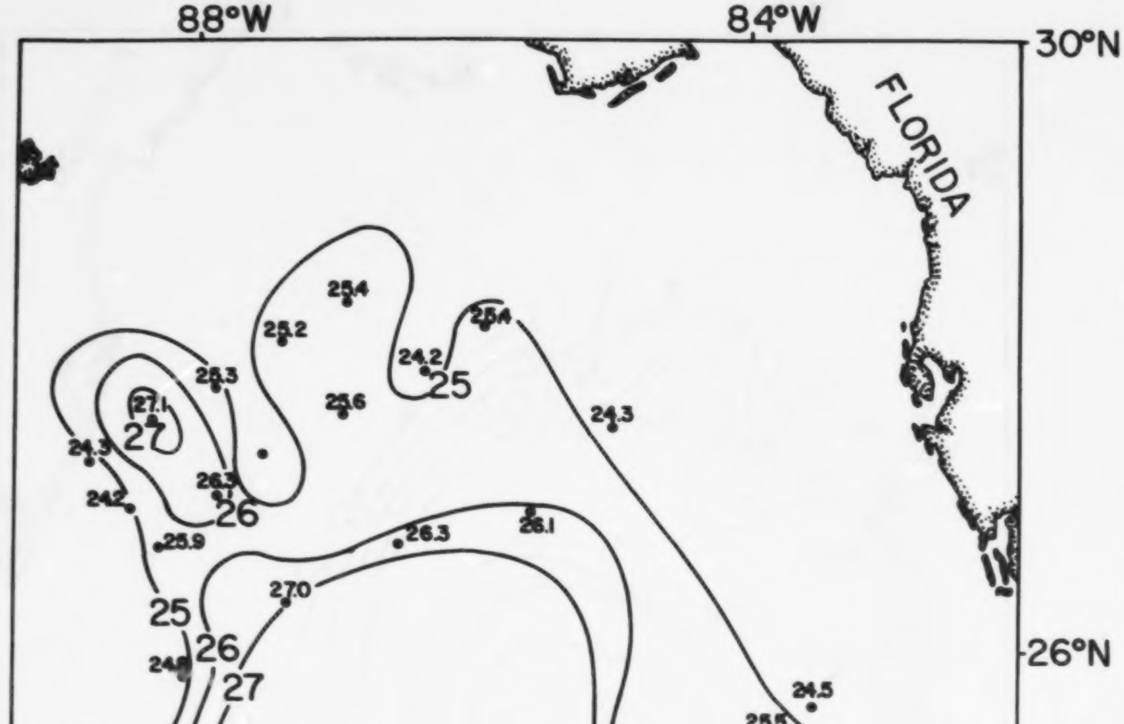
Legends to Figures

Figure 1	Sea surface temperature during Leg II, EGMEX-70-I, May, 1970.
Figure 2	Surface standing crop (No./1000M^3) of *Globigerinoides trilobus* during EGMEX-70-I, May, 1970.
Figure 3	Vertical section of standing crop of *Peraclis bispinosa* during EGMEX-70-I, May, 1970 (Austin, 1971).
Figure 4	Vertical section of salinity and standing crop (No./1000M^3) of pteropods during EGMEX-70-I, May, 1970 (Austin, 1971).
Figure 5	Depth of the 18°C isotherm during EGMEX-70-I (May, 1970), and standing crop of *Globorotalia crassiformis* coincident with the depth of the 18°C isotherm (from Austin, 1971).
Figure 6	Vertical section (depth vs. time) during a 24 hour anchored time series.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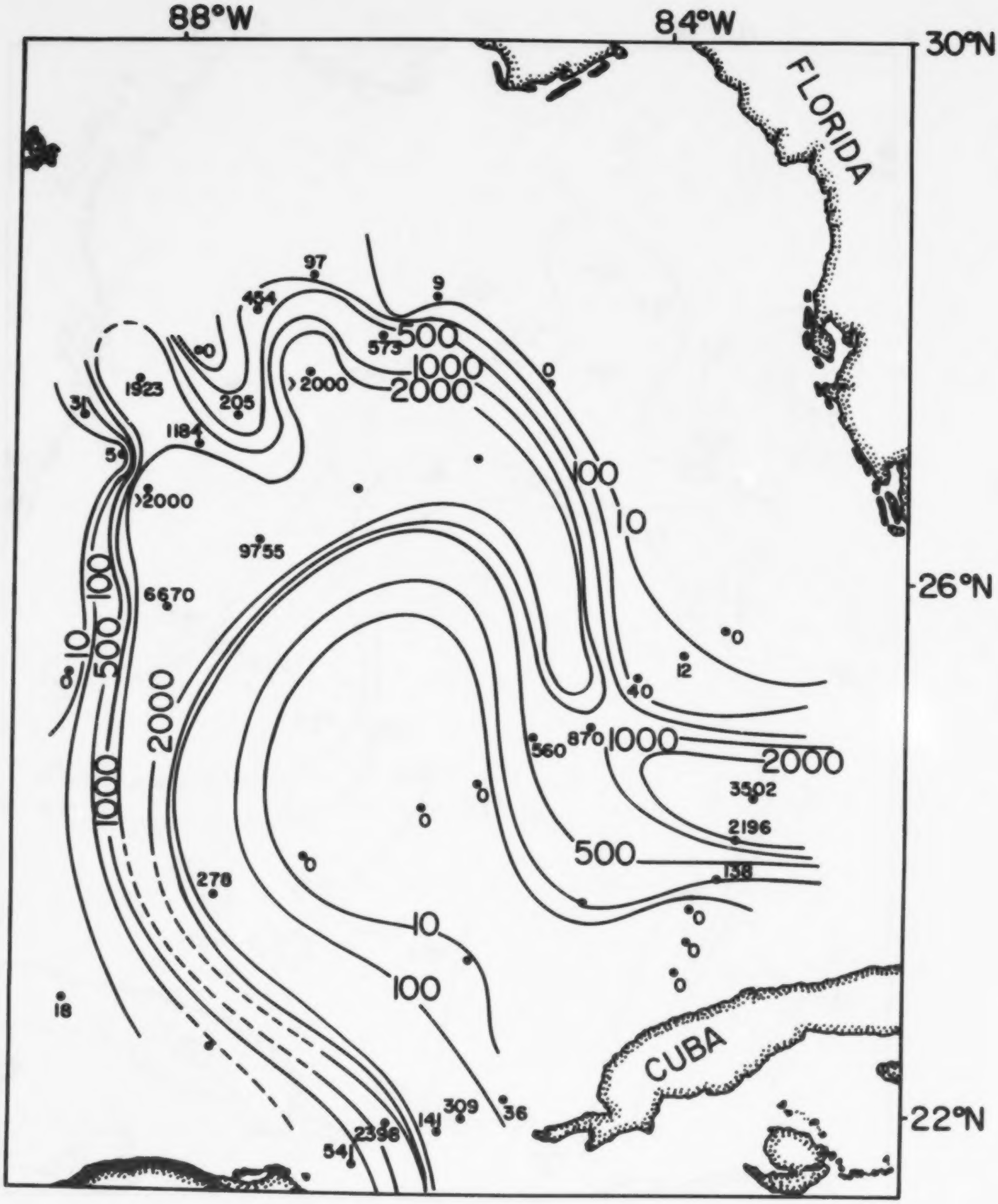

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541

FIGURE 2.

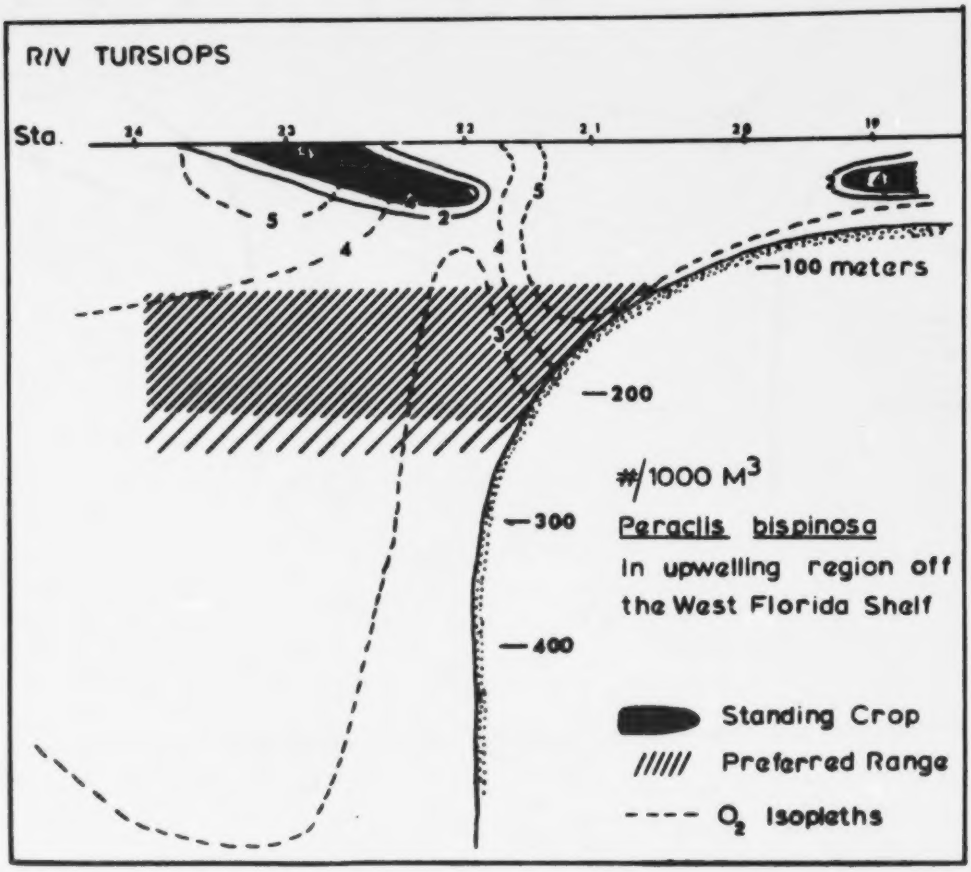
R/V TURSIOPS
Sta.
24
23
22
21
20
19
5
4
2
5
4
3
—100 meters
—200
—300
—400
#/1000 M³
Peraclis bispinosa
In upwelling region off the West Florida Shelf
Standing Crop
////// Preferred Range
---- O₂ Isopleths

FIGURE 3.

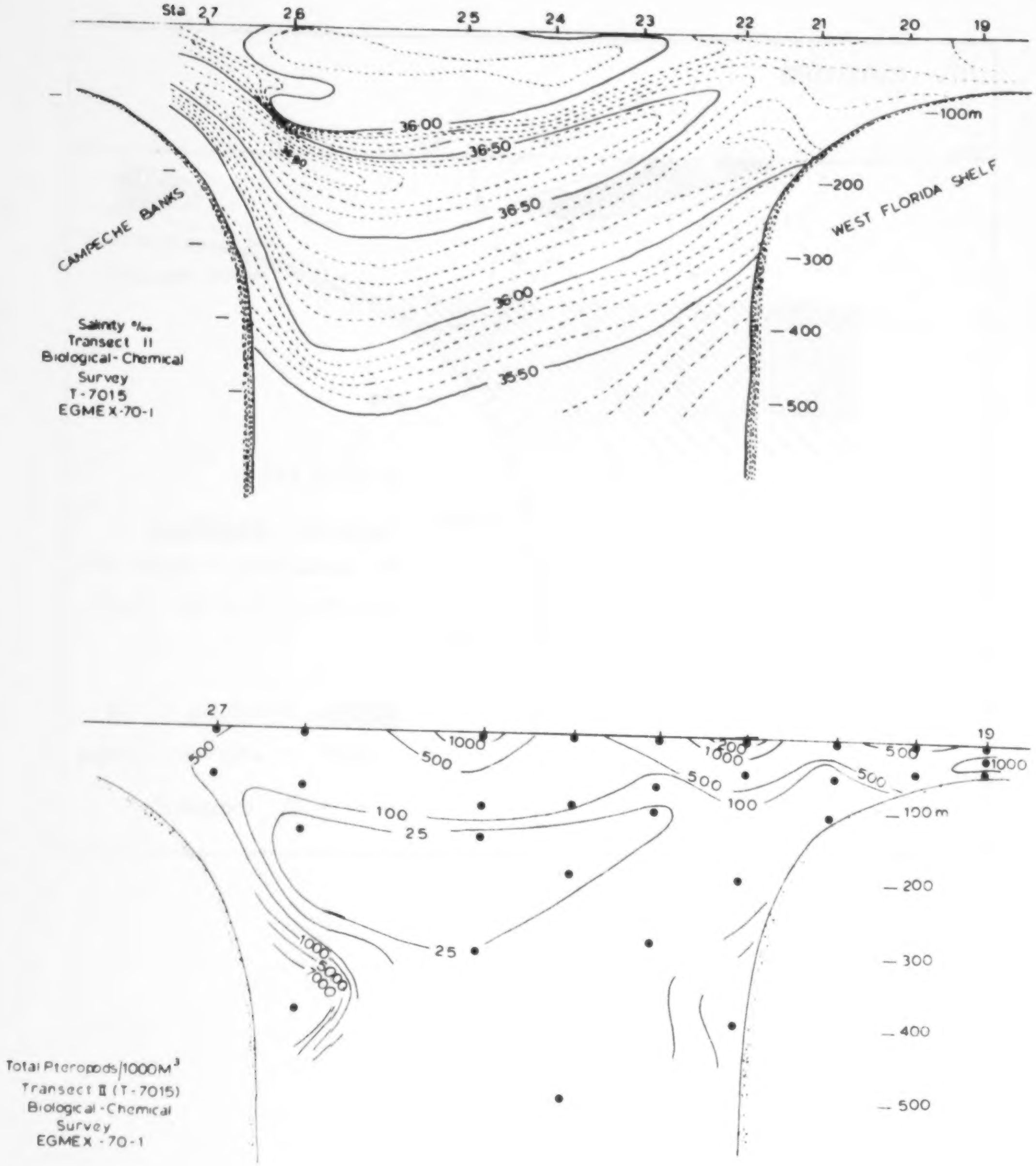
Sta 27 26 25 24 23 22 21 20 19
36·00
36·50
36·50
36·00
35·50
-100m
-200
-300
-400
-500
CAMPECHE BANKS
WEST FLORIDA SHELF
Salinity ‰
Transect II
Biological-Chemical
Survey
T-7015
EGMEX-70-1
27
19
500
1000
500
200
1000
500
500
500
1000
100
100
25
25
1000
5000
7000
-100m
-200
-300
-400
-500
Total Pteropods/1000M³
Transect II (T-7015)
Biological-Chemical
Survey
EGMEX-70-1

FIGURE 4.

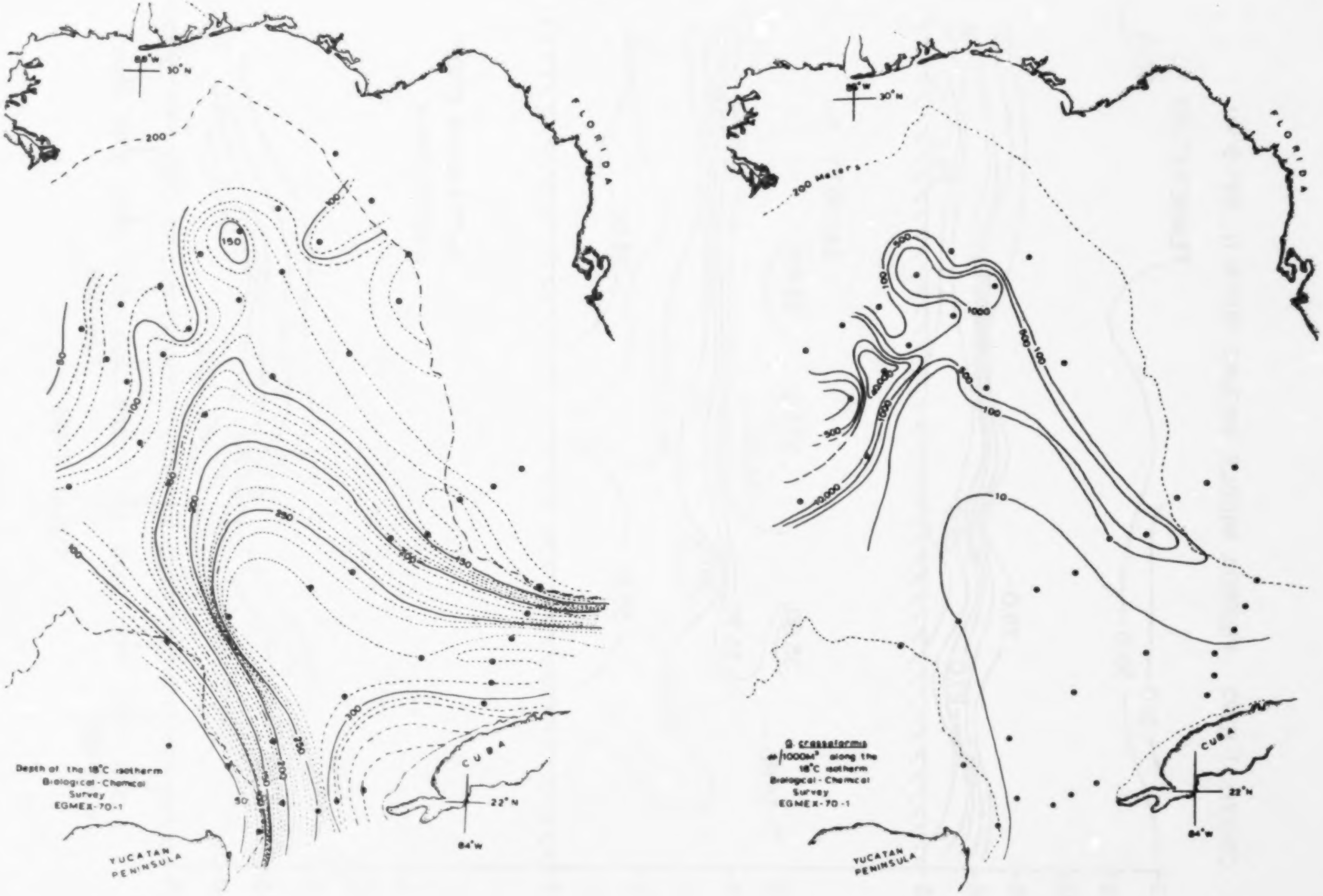
88°W
30°N
200
FLORIDA
150
50
100
200
250
300
Depth of the 18°C isotherm
Biological-Chemical
Survey
EGMEX-70-1
CUBA
22°N
84°W
YUCATAN
PENINSULA
88°W
30°N
200 Meters
500
100
1000
10,000
10
G. crassaformis
#/1000M³ along the
18°C isotherm
Biological-Chemical
Survey
EGMEX-70-1

FIGURE 5.

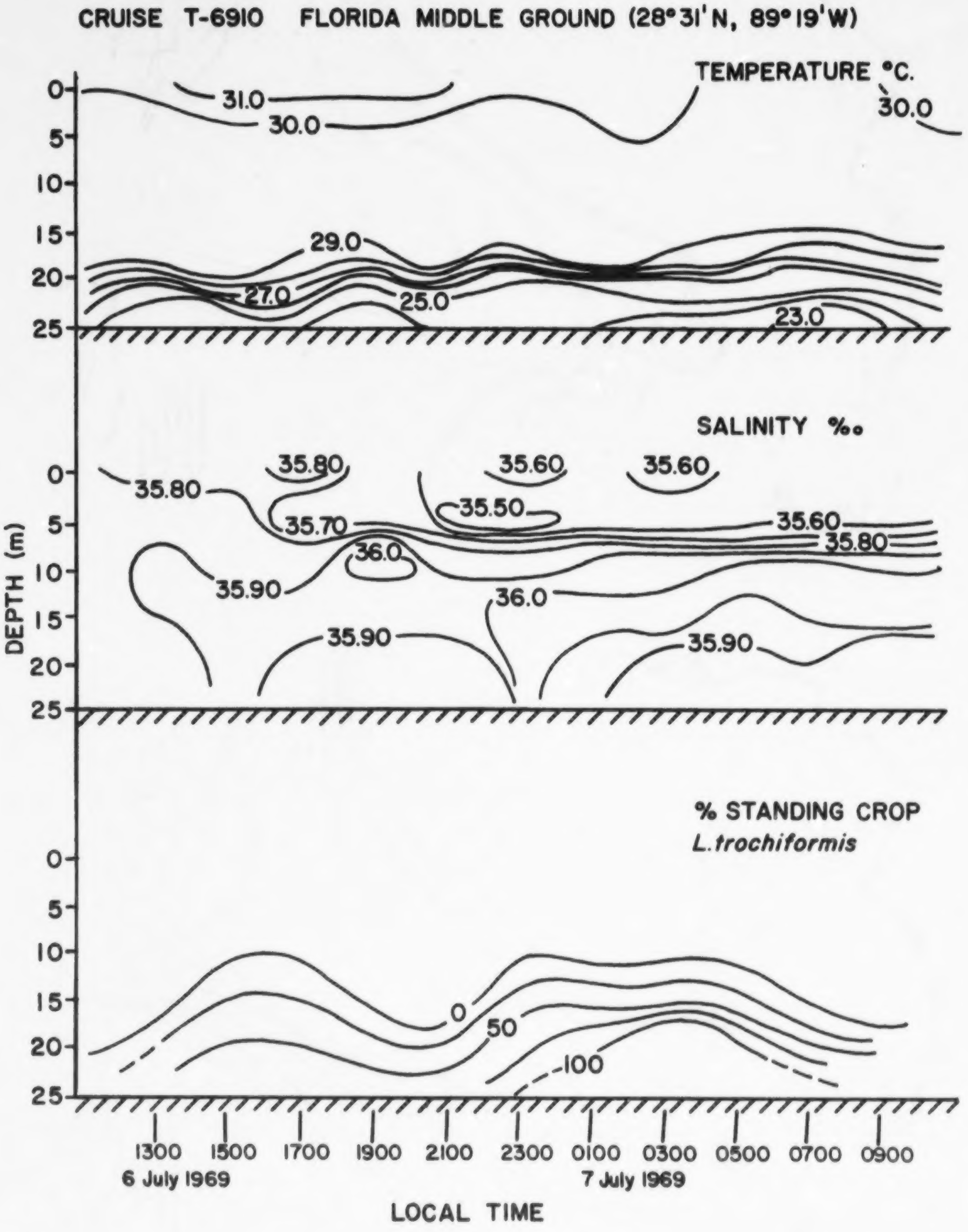
CRUISE T-6910 FLORIDA MIDDLE GROUND (28°31'N, 89°19'W)
TEMPERATURE °C.
31.0
30.0
30.0
29.0
27.0
25.0
23.0
SALINITY ‰
35.80
35.80
35.60
35.60
35.50
35.70
35.60
35.80
36.0
35.90
36.0
35.90
35.90
% STANDING CROP
L. trochiformis
0
50
100
DEPTH (m)
0
5
10
15
20
25
1300
1500
1700
1900
2100
2300
0100
0300
0500
0700
0900
6 July 1969
7 July 1969
LOCAL TIME

FIGURE 6.

Research on Eggs and Larvae of Fishes in the Eastern Gulf of Mexico

Edward D. Houde
Rosenstial School of Marine and Atmospheric Science
University of Miami
Miami, Florida

Introduction

In addition to being interesting biological material, the eggs and larvae of fishes are studied by fishery scientists for practical reasons. Abundance and distribution of the early life stages reflects the distribution and abundance of adult spawners in a given area. Spawning seasons and areas can be determined. If seasonal surveys are carried out, migrations of adults that spawn over long time periods can be examined. Egg and larval stages are the most delicate in the life of fishes and year class strength is thought to be fixed during those stages.

It frequently is easier to study eggs and larvae than juvenile or adult fishes because there is relatively little avoidance of collecting gear by eggs and larvae. Plankton nets are effective samplers for eggs and larvae of most marine fishes because the early life stages usually are pelagic, and most individuals are found in the top 100 m of the water column. Even such demersal fishes as flounders, snappers and groupers have pelagic eggs and larvae.

Egg and larval surveys can be used to estimate adult biomass in resource assessment programs, and my research has this goal in the Eastern Gulf of Mexico. If the mean fecundity, mean adult weight, sex ratio, and spawning season are known, the adult biomass can be estimated (Ahlstrom, 1968). Because there are many heavily exploited and also some underexploited species in the Eastern Gulf, this type of research is valuable to predict fisheries potential as well as annual fluctuations in abundance. A number of clupeid (sardine-like) fishes are present, but unexploited, in the Eastern Gulf and these are the immediate concern of my research. Egg and larval studies should be expanded to include the commercially exploited fishes such as snappers, groupers, mullets, and mackerel; gamefish species also could be studied, including dolphins, billfish and tunas. The possible effects of oil exploration or oil spills on spawning by these fishes add impetus to the need for research.

Historical Aspects of Egg and Larvae Research in the Eastern Gulf

Prior to 1969 there were no surveys of eggs and larvae that were designed to determine adult population sizes or fisheries potential in the Eastern Gulf. There are several references to eggs and larvae in literature on zooplankton from the Eastern Gulf (e.g. Dragovich, 1963; Kelly and Dragovich, 1967). Descriptions of egg and larval development, and records of occurrence also appear (e.g. Eldred, 1966; 1967; 1968; 1969; 1971). Other literature consists of notes on some phenomenon associated with spawning or egg and larval stages (e.g. Arnold and Thompson, 1958; Chapoton, 1967; Hettler, 1968).

The Hourglass Project of the Florida Department of Natural Resources (Joyce and Williams, 1969) provided collections of fish eggs and larvae from transects off Tampa Bay and Charlotte Harbor on a monthly basis for 28 months during 1965-1967. Descriptions, records of occurrence, and distribution data have been published based on these collections (e.g. Futch, 1971; Futch and Hoff, 1971).

Other studies by the Florida Department of Natural Resources have examined fish eggs and larvae. Wollam (1969) reported larvae of the wahoo from the Eastern Gulf, indicating that this important gamefish spawns from collections made in the Eastern Gulf (Wollam, 1970), showing that both species spawned on the continental shelf off western Florida. Dwinell and Futch (1973) collected larvae of king and Spanish mackerel from transects in the northeastern corner of the Gulf from June to October, 1969.

The National Marine Fisheries Service (NMFS) examined some plankton collections from the Eastern Gulf to determine distribution and abundance of menhaden eggs and larvae as part of their life history studies. Turner (1969) reported spawning centers nearshore during winter in the northeastern Gulf and near Charlotte Harbor off southwest Florida. Gulf menhaden eggs and larvae were most abundant during winter at a mean distance of 18 miles offshore in collections made between the Mississippi delta and Mobile Bay (Fore, 1970). Fore (1971) also reported round herring eggs and larvae during winter from areas farther offshore than Gulf menhaden. An extensive survey of spawning in the nearshore environment was completed during 1971 by the St. Petersburg Beach NMFS Laboratory as part of the South Florida Environmental Project. These collections were made between Cape Romano and Cape Sable on the southwest Florida coast; data are presently being analyzed.

The EGMEX and Western Florida Continental Shelf Programs began in 1970 and continued until 1972 (Rinkel, 1971 and 1974). As part of these surveys of physical, chemical and biological problems in the Eastern Gulf, estimates of fish egg and larvae abundance were made. Eggs and larvae were collected as part of the University of Miami's Sea Grant program and by the NMFS as part of the Marine Monitoring and Assessment Program (MARMAP). Rinkel (1971 and 1974) has discussed the cooperative effort that contributed to these programs and has summarized much of the cruise and station data. Some preliminary results of the egg and larvae research have been published (Houde, 1973; Houde and Fore, 1973).

The University of Miami Sea Grant
Egg and Larval Survey

Primary importance was attached to assessment of abundance of clupeid stocks in the Eastern Gulf because these offered the most obvious potential source of increased harvests to commercial fishermen (Bullis and Carpenter, 1968; Wise, 1972). My research has been confined to clupeid eggs and larvae and some results are presented in this report. Larvae and juveniles of other fishes from these collections are being studied by the NMFS, Southeast Fisheries Center, Miami, and will be reported on by that agency when data analysis is completed.

A grid of stations at 15 mile intervals was designed (Figure 1) and samples have been collected from 15 cruises between 1971 and 1973. Not all stations have been sampled on each cruise. Recent cruises have sampled between 50 and 60 of the 185 stations on the grid. Stations extend from the 5 fathom to the 100 fathom contour, with a few stations extending beyond the 100 fathom line. The 60 cm diameter Bongo net plankton sampler with 505 and 333 μ meshes has been towed in oblique hauls from near bottom, or 200 m, to surface. Temperature and salinity date from hydrocasts, BT, and STD traces have been obtained at each station; plankton volumes were determined from the 333 μ net catch. Five cruises were completed during each of the three years that the survey has been run.

Thread herring: This species is abundant and is found nearshore in the Eastern Gulf. Kinnear and Fuss (1971) recently discussed adult distribution and migrations. Spawning, and abundance of eggs and larvae were reported (Houde, 1973) for the 1971 season. Most eggs were distributed within 40 miles of the Florida coast (Figures 2 and 3) and spawning was most intense during spring and summer between Ft. Myers and Tampa Bay in both 1971 and 1972. Distribution of larvae reflects the egg distribution but is somewhat more widespread (Figures 4 and 5). The distribution of larvae ≤ 5 mm length may be a better indicator of spawning than the egg distribution, because the small larvae are less than 3 days old and their distribution is less patchy than that of eggs. A preliminary and conservative estimate of 350,000 metric tons has been obtained for adult thread herring biomass, most of which is found between Ft. Myers and Tampa Bay. The estimate is conservative because spawning probably is more intense nearer to shore than our survey grid extends. Two cruises scheduled for 1974 will sample nearshore areas to investigate this possibility. Thread herring must be considered a large, potential fishery resource in the Eastern Gulf. Presumably, they also constitute an important food source for some predatory game and commercial fishes.

Menhaden: Two species of menhaden are found in the Eastern Gulf. Most individuals north of Tampa Bay are the commercially important Gulf menhaden; those south of Tampa Bay are largely yellowfin menhaden. Eggs and larvae occur during winter and are found nearshore in the northeastern Gulf and along the southwest Florida coast (Figures 6 and 7). They are not as common as thread herring or round herring in the Eastern Gulf.

Round herring: The round herring apparently is abundant on the outer shelf in the Eastern Gulf. It spawns during winter, mostly between 30 and

200 m depths, but some spawning occurs even farther offshore. There appear to be two spawning centers for this species; one occurs near the Tortugas Islands and the other, the most important area, occurs off Tampa Bay. Egg and larval distributions during January 1973 are typical of those observed during other cruises in 1971 and 1972 (Figures 8, 9 and 10). Preliminary estimates indicate that a minimum adult biomass of 250,000 metric tons is present in the Eastern Gulf. Round herring eggs and larvae occur in the oil lease areas and spawning might be temporarily affected by an oil spill or other disturbances due to oil exploration.

Other Clupeoid Fishes; Spanish sardines, scaled sardines, and anchovies occur in abundance in the Eastern Gulf. Scaled sardines spawn nearshore in spring and summer. They are common but apparently not as abundant as thread herring. Spanish sardines spawn from fall to spring and their eggs and larvae are widespread in the Eastern Gulf. No good estimates of abundance are yet available for Spanish sardines. At least three species of anchovies occur in the Eastern Gulf. Their larvae are common in plankton collections but adult abundance cannot be estimated until specific identification is made of eggs and larvae. Both anchovy and Spanish sardine eggs and larvae commonly occur in the areas of the oil lease sites.

National Marine Fisheries Service
MARMAP Program

Much of the data collected as part of the University of Miami Sea Grant Program was a cooperative effort in conjunction with development of the ichthyoplankton survey that was a part of the NMFS Marine Monitoring and Assessment Program (MARMAP). Aprieto (1972) has determined distribution and abundance of larvae of 10 carangid species in the Gulf of Mexico based on these data. She found that 45% of all carangid larvae that were collected were round scad, and that most occurred on the outer continental shelf in the Eastern Gulf. Both Metziger (1973) and Wilkens (manuscript) examined effects of variations in Bongo net collecting technique on certain aspects of egg and larval catches. In addition to plankton samples, NMFS is analyzing a large volume of neuston net data from which distributions of larvae and juveniles of some important game and commercial species such as tuna, billfishes and dolphin will be determined.

Future Needs for Egg and Larvae Research

Seasonal surveys should be continued to monitor abundance of important species in the Eastern Gulf. One drawback of egg and larval surveys is the time lag between collections and completion of data analysis. Future surveys should provide enough help to quickly sort and identify fish eggs and larvae so that useful information can be relayed to industry or concerned parties in a short time frame. The number of species routinely surveyed should be increased to include heavily exploited species such as mullet, snappers, groupers, and mackerel, as well as some fishes that can be considered indicator organisms, such as the dusky flounder and round scad whose larvae are abundant over much of the Eastern Gulf.

Studies on the taxonomy of eggs and larval stages are needed. Eggs of only a few species are recognized from the Eastern Gulf and larvae of many species cannot be classified beyond the family level. These types of studies would be particularly valuable with respect to snappers and groupers, because most species cannot be recognized yet in the larval stage.

Nearshore surveys of eggs and larvae are needed to complement more extensive research that has been completed on the outer shelf. Some economically important species apparently complete their life cycles in Eastern Gulf estuaries or not far offshore. These include the sciaenid fishes such as seatrout, drum, and croakers. A survey by NMFS from Cape Romano to Cape Sable, that is now being completed, will provide valuable data on nearshore spawning by Gulf fishes. Jannke (1971) surveyed larvae of sciaenid fishes in Little Shark River, an estuary in Everglades National Park. Other estuary systems also should be studied to determine which are important spawning and nursery areas in the Eastern Gulf.

Egg and larvae surveys are of potential use to evaluate changes in abundance of certain species that might occur as a result of oil exploration and production. It is well known that sportfishing catches are enhanced near platforms and drilling rigs in the Gulf of Mexico. But, a controversy has arisen regarding whether abundance of fish has increased or whether they have simply been concentrated around the platforms. Any significant change in abundance of planktonic eggs and larvae could be measured and would be a reflection of changes in adult stock size. Because eggs and larvae are more or less at the mercy of water currents, they would be dispersed from the immediate vicinity of platforms, and because they offer relatively little avoidance to sampling gears their abundance would provide an accurate estimate of adult abundance in a sampling area. Surveys of eggs and larvae also would be of obvious value to determine any effects on spawning success that might result if an extensive oil spill occurred.

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Figure Legends

Figure 1. Sampling stations for eggs and larvae of fishes, used by the University of Miami Sea Grant program and the National Marine Fisheries Service MARMAP program from 1971 to 1973.

Figure 2. Distribution and abundance of thread herring eggs in the Eastern Gulf of Mexico during May 1971.

Figure 3. Distribution and abundance of thread herring eggs in the Eastern Gulf of Mexico during August 1971.

Figure 4. Distribution and abundance of thread herring larvae ≤ 5.0 mm in length in the Eastern Gulf of Mexico during May 1971.

Figure 5. Distribution and abundance of thread herring larvae of all lengths in the Eastern Gulf of Mexico during May 1971.

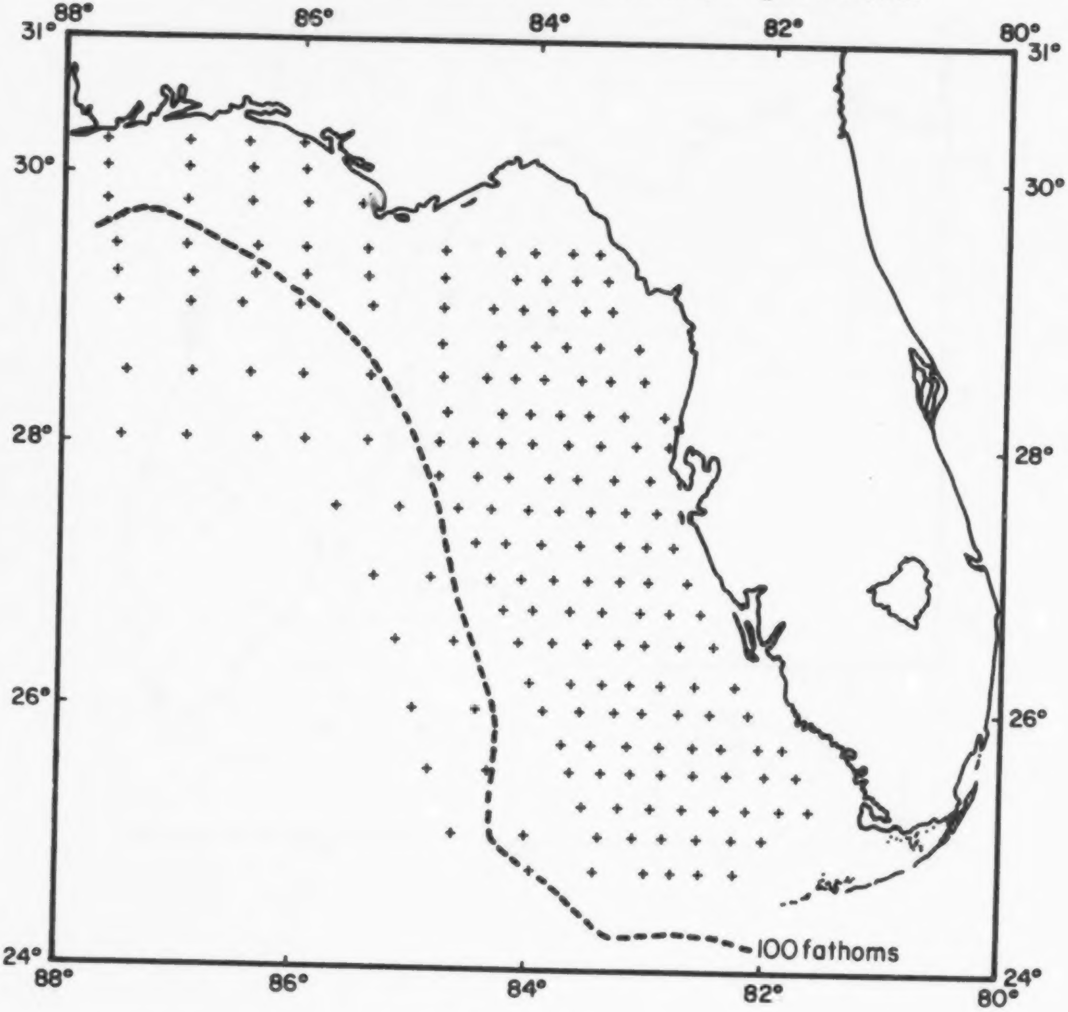
Figure 6. Distribution and abundance of menhaden eggs in the Eastern Gulf of Mexico during January 1973.

Figure 7. Distribution and abundance of menhaden larvae of all lengths in the Eastern Gulf of Mexico during January 1973.

Figure 8. Distribution and abundance of round herring eggs in the Eastern Gulf of Mexico during January 1973.

Figure 9. Distribution and abundance of round herring larvae ≤ 5.0 mm in length in the Eastern Gulf of Mexico during January 1973.

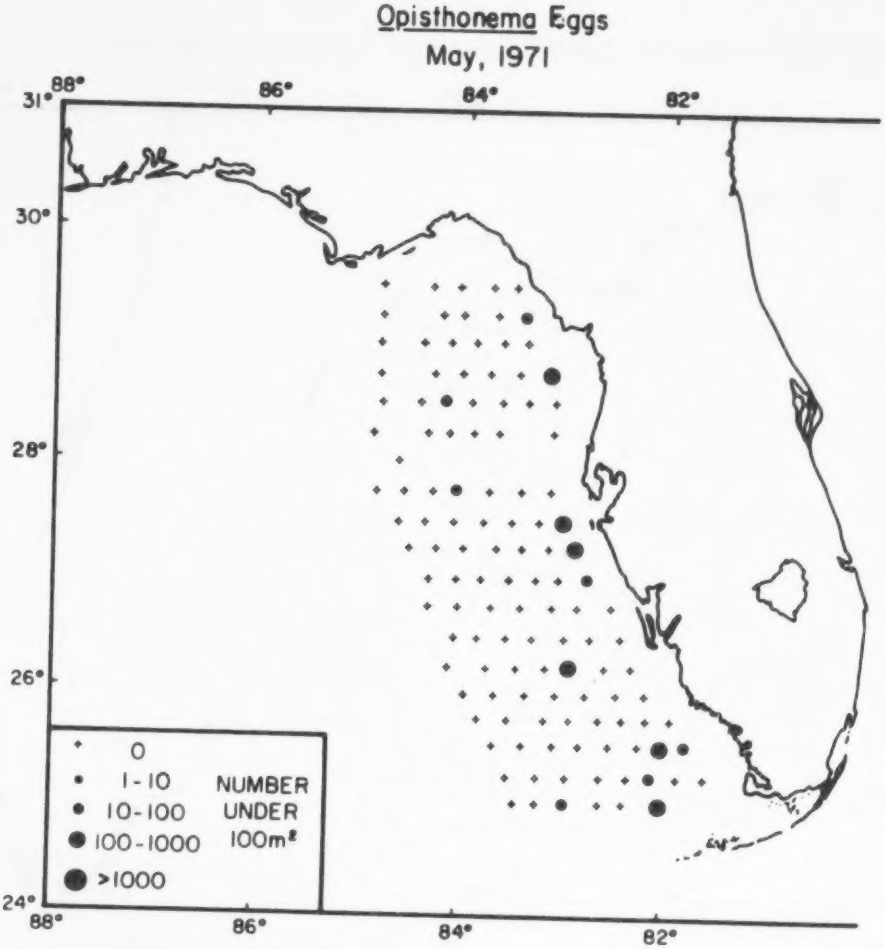
Figure 10. Distribution and abundance of round herring larvae of all lengths in the Eastern Gulf of Mexico during January 1973.



Eastern Gulf of Mexico Ichthyoplankton Sampling Stations.

88°
86°
84°
82°
80°
31°
30°
28°
26°
24°
100 fathoms

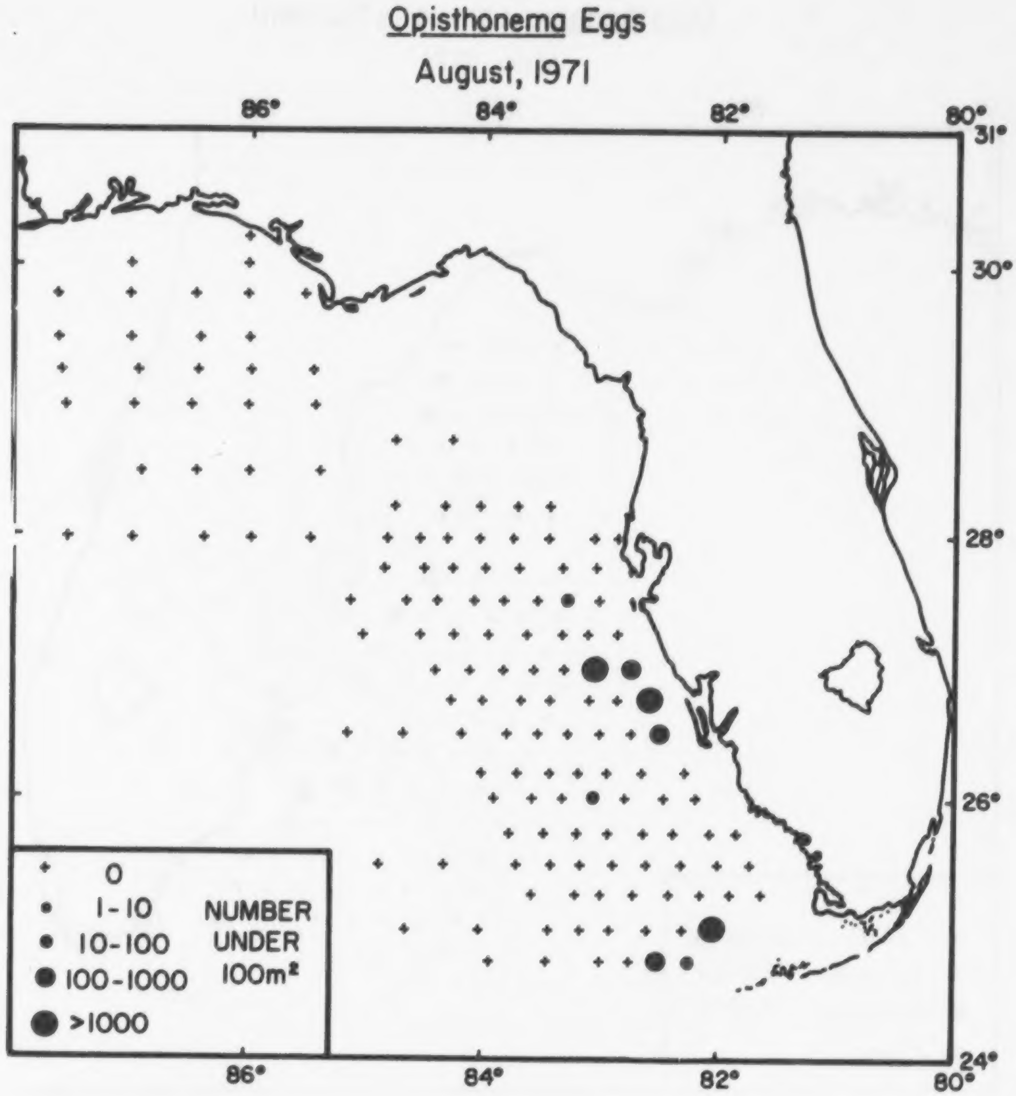
FIGURE 1.



Opisthonema Eggs
May, 1971

88°
86°
84°
82°
31°
30°
28°
26°
24°
88°
86°
84°
82°
0
1-10
10-100
100-1000
>1000
NUMBER
UNDER
100m²

FIGURE 2.



Opisthonema Eggs

August, 1971

86°
84°
82°
80°
31°
30°
28°
26°
24°
+ 0
• 1-10
• 10-100
● 100-1000
● >1000
NUMBER UNDER 100m²

FIGURE 3.

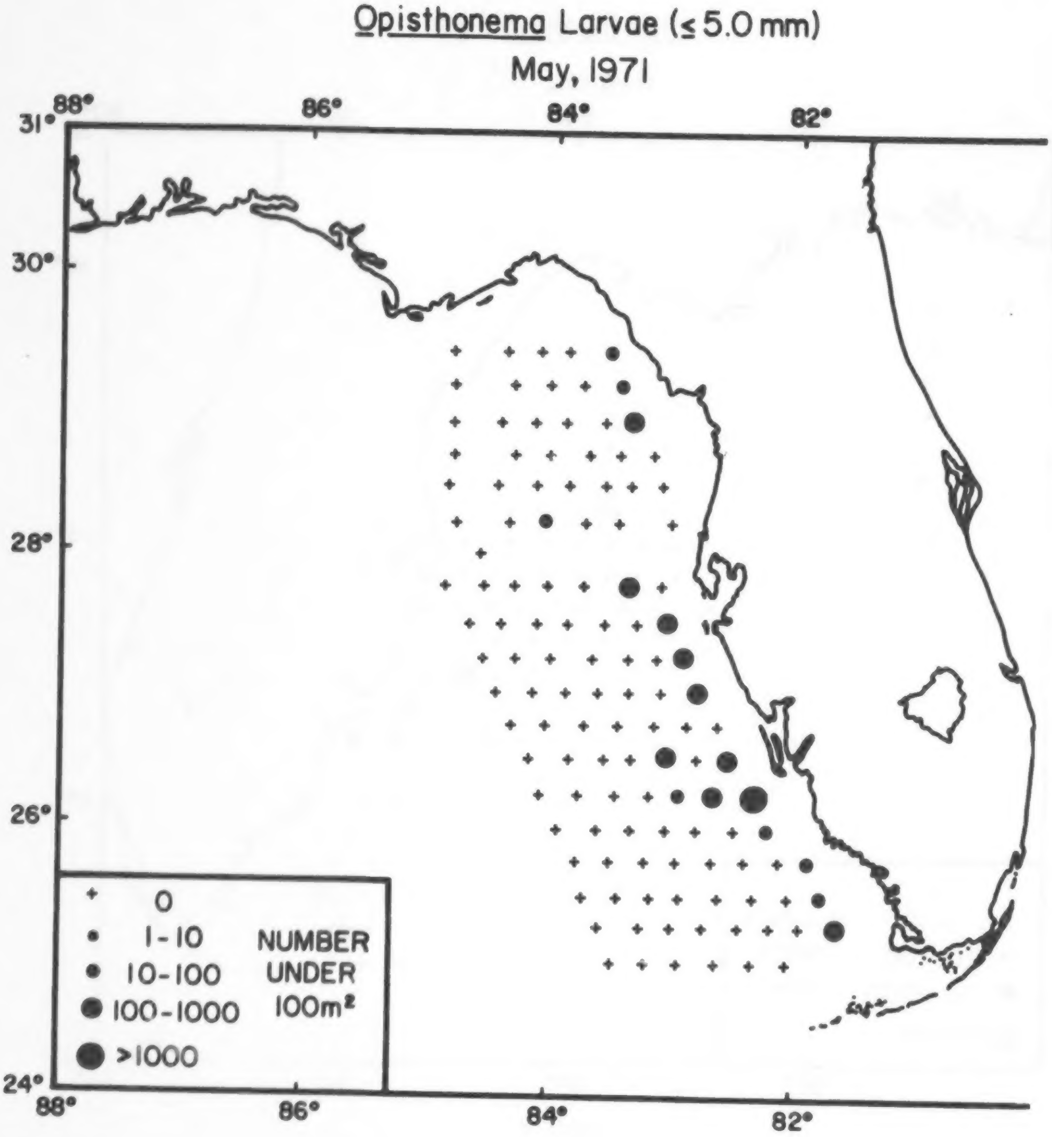
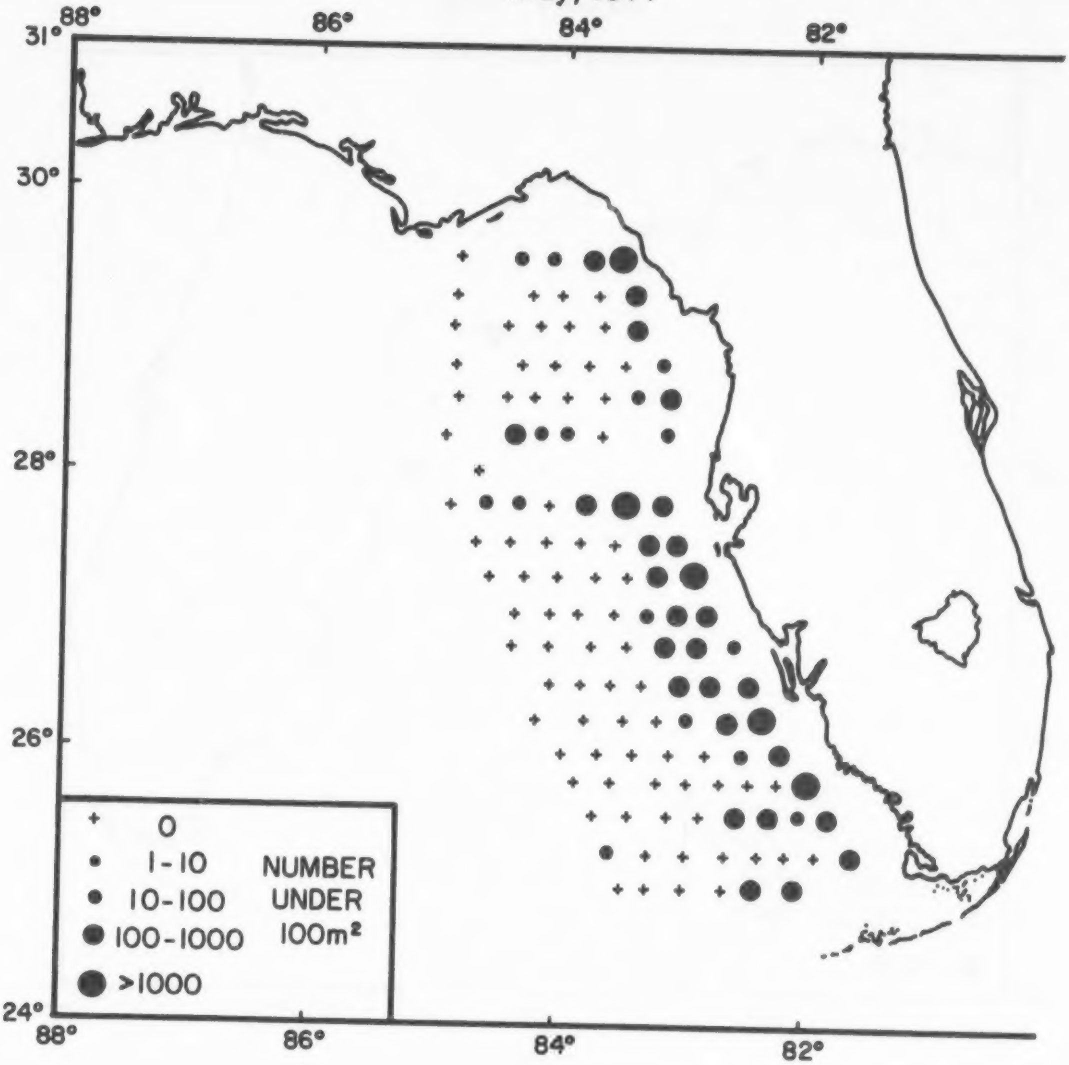

Opisthonema Larvae (≤ 5.0 mm)
May, 1971
88°
86°
84°
82°
31°
30°
28°
26°
24°
+ 0
• 1-10
● 10-100
● 100-1000
● >1000
NUMBER UNDER 100m²

FIGURE 4.



Opisthonema Larvae (all sizes)
May, 1971

88°
86°
84°
82°
31°
30°
28°
26°
24°
+ 0
• 1-10
● 10-100
● 100-1000
● >1000
NUMBER UNDER 100m²

FIGURE 5.

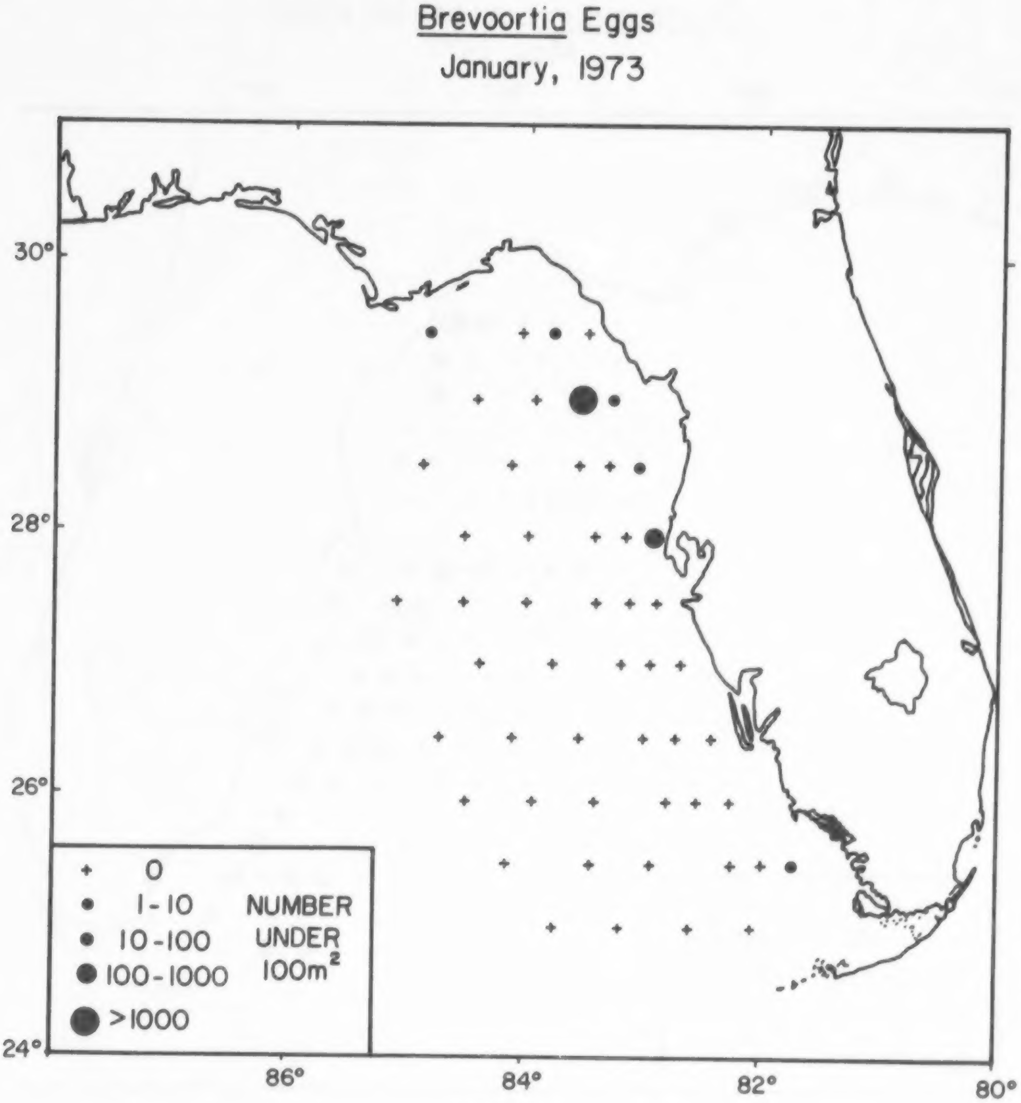
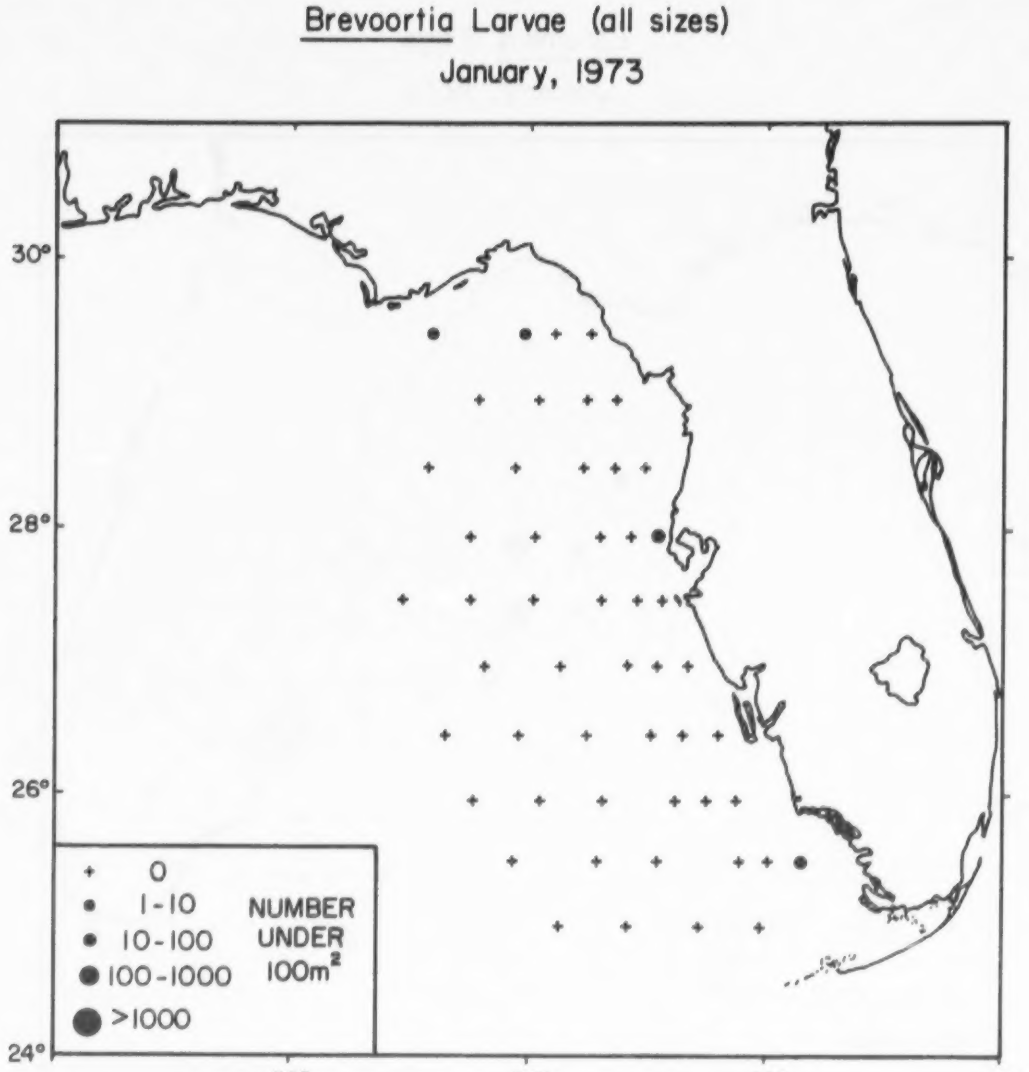

Brevoortia Eggs
January, 1973
30°
28°
26°
24°
86°
84°
82°
80°
+ 0
• 1-10
• 10-100
● 100-1000
● >1000
NUMBER UNDER 100m²

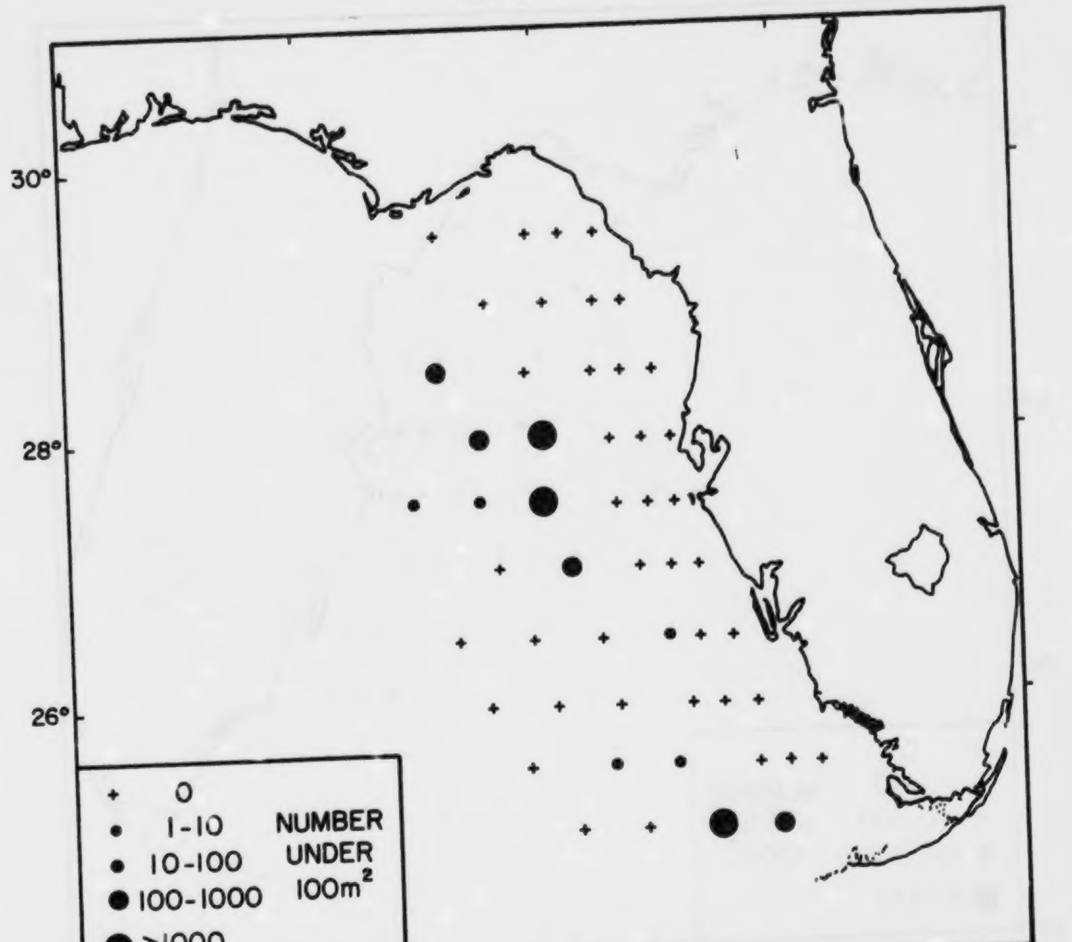
FIGURE 6.



Brevoortia Larvae (all sizes)
January, 1973

30°
28°
26°
24°
86°
84°
82°
80°
+ 0
• 1-10
• 10-100
● 100-1000
● >1000
NUMBER
UNDER
100m²

FIGURE 7.



Etrumeus Eggs

January, 1973

30°
28°
26°
24°
86°
84°
82°
80°
+ 0
• 1-10
• 10-100
● 100-1000
● >1000
NUMBER
UNDER
100m^2

FIGURE 8.

Etrumeus Larvae (≤ 5.0 mm)
January, 1973

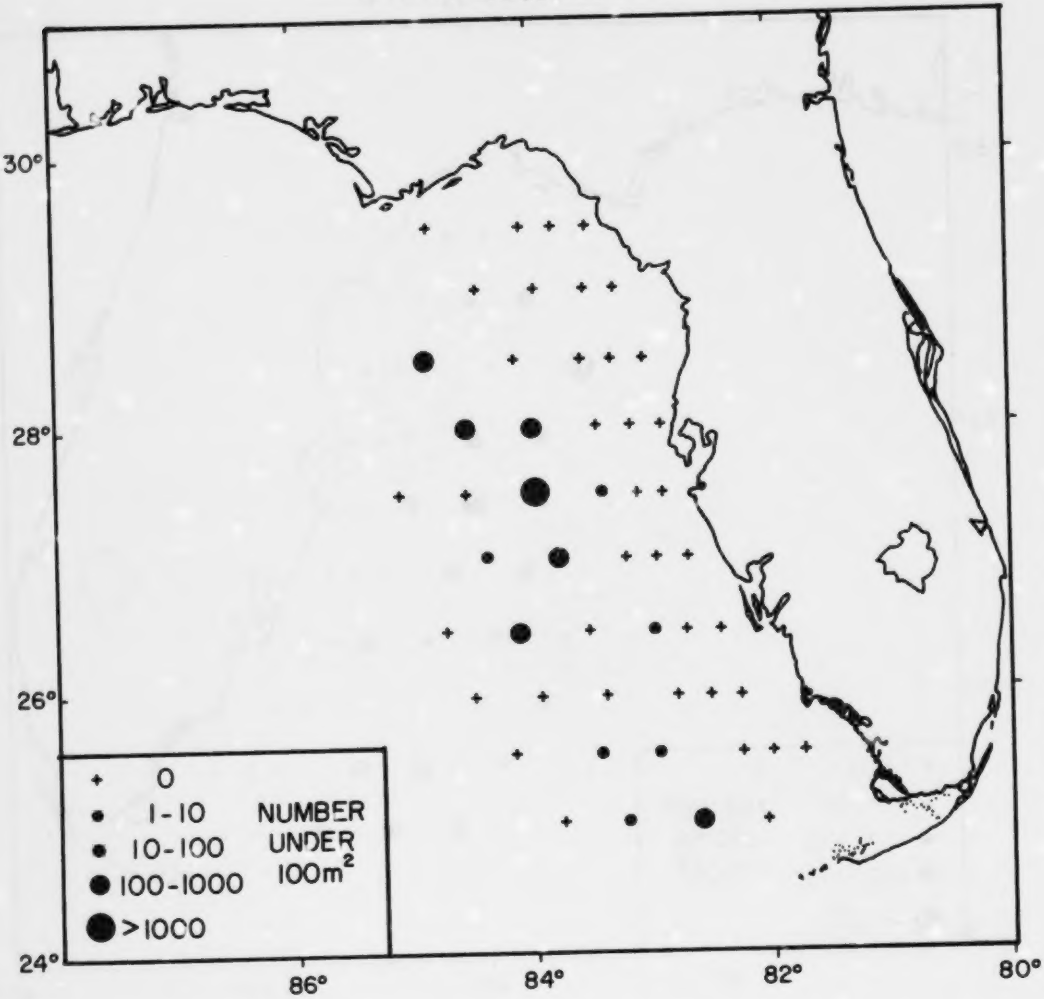
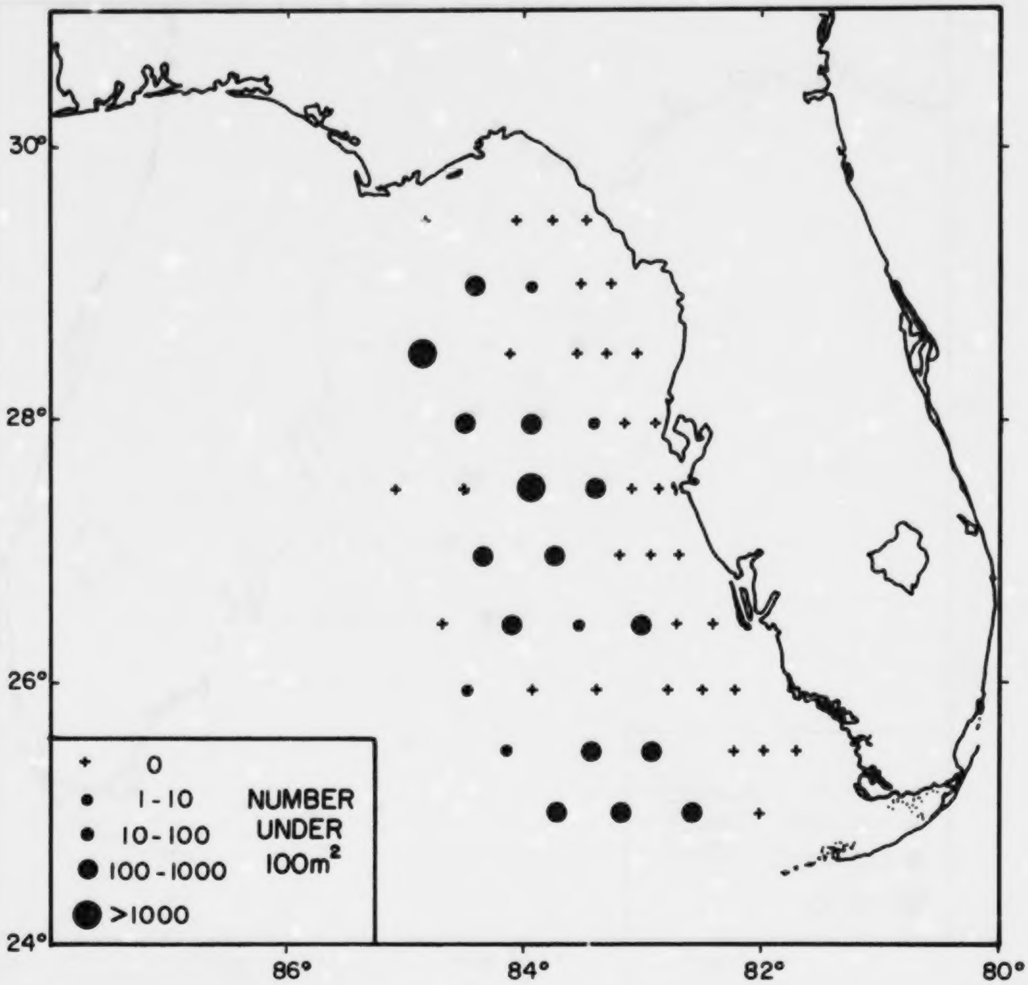

30°
28°
26°
24°
86°
84°
82°
80°
+ 0
• 1-10
• 10-100
● 100-1000
● >1000
NUMBER UNDER 100m²

FIGURE 9.



Etrumeus Larvae (all sizes)
January, 1973

30°
28°
26°
24°
86°
84°
82°
80°
+ 0
● 1-10
● 10-100
● 100-1000
● >1000
NUMBER UNDER 100m²

FIGURE 10.

Nature and Status of the Marine Sport Fishery in the Eastern Gulf of Mexico

Prepared by Luis R. Rivas
NOAA/National Marine Fisheries Service
Gulf Coastal Fisheries Center
Panama City, Florida

Presented by Harvey R. Bullis, Jr.
NOAA/National Marine Fisheries Service
Southeast Fisheries Center
Miami, Florida

Introduction

In the eastern Gulf of Mexico the marine sport fishery may be subdivided into several categories according to the areas where fishing is conducted and the method used. For example, in the coastal fishery are included fishing activities conducted from the shore, piers, bridges, and jetties. The offshore category comprises activities such as trolling for billfishes and tunas from private or charter boats. Overlap between these two categories is shown by certain types of fishing that cannot be classified as either offshore or coastal. Also, some bottom fishing, although conducted from boats, is done so close to shore that it could almost be classified as pier or jetty fishing.

In this report the marine sport fishery of the eastern Gulf of Mexico is considered as extending from the mouth of the Mississippi River eastward and southward to the Florida Keys. It is estimated that every year, in this region of the Gulf, 1,480,000 anglers catch 178,277,605 fish weighing 339,832,049 pounds. It is also estimated that the annual sum spent in marine sport fishing in the eastern Gulf amounts to $263,588,000.

Coastal Fishery

In this category are included fishing activities conducted from the beach, pier, bridge or jetty. Along the eastern Gulf, beaches may front the open ocean as in the area between Pensacola and Panama City or they may be located in a bay or estuary. Piers are usually located at open ocean beaches such as Destin and Panama City. Bridges are located within bays or near their entrance. Jetties are located at either side of a ship channel usually at a bay entrance. In Louisiana, around the mouth of the Mississippi River, oil rigs attract and concentrate many fish especially red snapper and several species of groupers. Oil rigs have become very popular sport fishing areas.

It is estimated that every year 266,000 anglers fish from the beach and 413,000 from bridge, pier, or jetty. The number of anglers is not additive since some anglers fished in both areas. The annual catch for the beach fisherman is estimated at 31,680,000 pounds and that for the bridge, pier, and jetty fishermen at 70,986,600 pounds. This gives an annual total of 102,666,600 pounds for the coastal fishery.

The species and annual number of individual fish caught are given in the following table.

	Species	Bridge, Pier, Jetty	Beach
1.	Bluefish	--	36,000
2.	Bonitos	179,000	--
3.	Croakers	4,332,000	2,546,000
4.	Drum, black	3,707,000	78,000
5.	Drum, red	1,276,000	934,000
6.	Flounder	469,000	849,000
7.	Groupers	203,000	--
8.	Grunts	3,576,000	374,000
9.	Jacks	674,000	114,000
10.	Ladyfish	215,000	69,000
11.	Mackerel, king	160,000	--
12.	Mackerel, Spanish	488,000	104,000
13.	Mullets	126,000	3,439,000
14.	Pompanos	251,000	36,000
15.	Porgies	4,587,000	1,940,000
16.	Seatrout, sand	5,577,000	1,172,000
17.	Seatrout, spotted	3,095,000	2,669,000
18.	Snapper, red	166,000	47,000
19.	Snapper, yellowtail	--	234,000
20.	Snook	50,000	--
21.	Spadefish	918,000	62,000
22.	Tarpon	50,000	--
23.	Miscellaneous	9,338,000	2,897,000
Totals		39,437,000	17,600,000

The above totals combine to form a grand total of 57,037,000.

Bottom Fishery

In this category are included bottom fishing activities conducted from private, rented, party, or charter boats. The annual number of anglers fishing from private or rented boats is estimated at 607,000 and the annual number fishing from party or charter boats at 323,000. These numbers are not additive since some anglers fished all boat categories. Also, the number of anglers participating exclusively in bottom fishing cannot be computed or even estimated because many of them conducted various other types of fishing. The annual catch of bottom fish, however, can be estimated at 203,439,600 pounds.

The species and annual number of individual bottom fish caught are given in the following table.

Species	No. of Fish	Species	No. of Fish
1. Bass, black sea	1,248,000	9. Perches	426,000
2. Catfishes	17,346,000	10. Porgies	6,707,000
3. Croakers	29,155,000	11. Puffers	23,000
4. Drum, black	617,000	12. Seatrout, sand	15,069,000
5. Drum, red	5,063,000	13. Seatrout, spotted	22,717,000
6. Flounder	3,103,000	14. Skates, rays	52,000
7. Groupers	2,935,000	15. Snapper, red	3,344,000
8. Grunts	4,870,000	16. Snapper, yelt.	347,000
Total	64,337,000	Total	48,685,000

The above totals combine to form a grand total of 113,022,000 individual fish per year.

Bottom fishing is one of the most popular types of fishing conducted in the eastern Gulf. Numerous boat ramps are provided all along the coast for the small private boats. The larger private boats are kept mostly in the many marinas available at Culfport, Biloxi, Pascagoula, Dauphin Island, Pensacola, Fort Walton Beach, Destin, Panama City, Homosassa, Clearwater, St. Petersburg, Tampa, etc. Party and charter boats are also available in these and other ports along the coast. These facilities and the great abundance of bottom fish attract not only the local anglers but also many from out of state, especially Tennessee and Georgia. The bottom fishery is conducted throughout the year but fishing is much more intense in the summer.

Groupers and snappers are the most popular bottom fishes taken in the eastern Gulf, especially the red snapper and the red grouper. Other groupers especially the scamp, the black grouper, and the gag, are also very popular and abundant and can be taken the year-round.

In the eastern Gulf bottom fishing is conducted within the Continental Shelf at depths usually not greater than 20 or 30 fathoms. Although there are many natural "reefs," "rocks," and "holes" which are favorite bottom fishing spots, wrecks are also favored and several artificial reefs have been constructed along the coasts of Mississippi, Alabama, and Florida. There are at least 20 along the Gulf coast of Florida of which four are located between Pensacola and Cape San Blas, five between St. Marks and Crystal River, four off Clearwater and St. Petersburg, six off the Bradenton-Sarasota area, and one between Sanibel Island and Cape Romano. Many others are being planned or are now under construction.

Offshore Fishery

This catagory includes trolling for king and Spanish mackerel near shore and trolling for billfishes, dolphin, and tunas much farther offshore. Among billfishes usually only the sailfish is occasionally taken incidental to trolling for king mackerel. Fishing for cobia may also be included in this category since this fish is taken at, or near, the surface, sometimes by trolling or usually by spotting the fish and presenting the bait.

The annual number of cobia, dolphin, king mackerel, Spanish mackerel, and tunas is presented in the following table.

Species	No. of Fish
1. Cobia	8,000
2. Dolphin	268,000
3. King mackerel	2,552,000
4. Spanish mackerel	1,701,000
5. Tunas	12,000
Total	4,541,000

The total combined weight of these five species is estimated at 27,058,000 pounds per year.

Statistics on billfish catch and effort in the eastern Gulf have been collected by the National Marine Fisheries Service, Southeast Fisheries Center, since 1971. According to the 1971 and 1972 data the annual catch of billfishes averages 605 individuals and a total weight of 49,249 pounds. The average annual catch by species, number of fish, and weight is given in the following table.

Species	No. of Fish	Weight (Pounds)
1. Blue marlin	85	23,630
2. White marlin	249	13,695
3. Sailfish	271	11,924

The catch-per-unit-of-effort (CPUE), in terms of number of fish caught per hour of trolling, the number of fish caught, and the hours trolled, for 1971, 1972, and 1973 is given in the following table.

1971	Species	No. Fish	No. Hours	CPUE
	1. Blue marlin	99	11,107	0.009
	2. White marlin	284	"	0.026
	3. Sailfish	318	"	0.029
	4. Total billfish	701	"	0.063

1972	Species	No. Fish	No. Hours	CPUE
1.	Blue marlin	70	12,300	0.006
2.	White marlin	213	"	0.017
3.	Sailfish	224	"	0.018
4.	Total billfish	507	"	0.041

1973	Species	No. Fish	No. Hours	CPUE
1.	Blue marlin	93	9,310	0.010
2.	White marlin	192	"	0.021
3.	Sailfish	53	"	0.006
4.	Total billfish	338	"	0.036

In the eastern Gulf, trolling for billfishes is conducted above the Continental Shelf from about 30 fathoms outward and also above the Continental Slope at depths of up to 500 fathoms (De Sota Canyon). Distance from shore varies from as little as 12 miles off the mouth of the Mississippi River, to 60 miles or more off the Clearwater-St. Petersburg area. The most important billfishing ports in the eastern Gulf are Port Eads at the mouth of the Mississippi (South Pass), Dauphin Island, Pensacola, Destin, Panama City, Clearwater, and St. Petersburg.

The billfish sport fishery was practically nonexistent in the eastern Gulf until about 20 years ago. Pioneered by the New Orleans Big Game Fishing Club it has grown tremendously in the past few years and it still continues to grow.

Miscellaneous Fisheries

In this category are included sport fishing activities that do not fit into the preceding categories and which are better discussed separately. The species involved are not strictly bottom fish and although they may be caught from shore, or trolling close to shore, they are usually taken from small boats with live bait or artificial lures by the methods called "bait casting," "plug casting," or "spin casting." These fishes are the barracuda, bluefish, jacks, ladyfish, snook, and tarpon. Except for the barracuda, which is not included in the preceding categories, catches for the others are also included in the coastal fishery section but only those taken from shore or shore structures. In addition to the ocean, close to shore, these fishes are taken in bays.

The annual catch of these species is estimated at 6,618,600 pounds. The annual number of individual fish taken is given in the following table.

	Species	No. of Fish
1.	Barracuda	4,000
2.	Bluefish	86,000
3.	Jacks	1,146,000

(contd.)

4. Ladyfish	1,607,000
5. Snook	401,000
6. Tarpon	433,000
Total	3,677,000

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Fishery Resources--Commercial

Rolf Juhl
NOAA/National Marine Fisheries Service
Southeast Fisheries Center
Pascagoula, Mississippi

Introduction

In agreement with the purpose of this Conference and Workshop to discuss the state-of-knowledge and information needs of the eastern Gulf, I intend to give you a condensed overview on the commercial fishery and fishery resources. Specific information on the subject is compiled in the paper entitled "Utilization of Marine and Coastal Resources" by John L. Taylor, et al., and the references contained therein.

The area under discussion extends from the Mississippi Delta to the Dry Tortugas. Here the area of the Continental Shelf is roughly 50,000 square miles; of this about 45,000 square miles lie inside the 50-fathom curve and about 12,000 lie inside 10 fathoms. The great majority of the fish production comes from inside the 50-fathom curve. The average distance from shore of the 10-fathom depth in this area is 20 miles, the 50-fathom depth 75 miles and the 100-fathom curve lies 85 miles from shore. The Continental Shelf off southern Florida extends almost 150 miles from shore and it narrows to 10-12 miles directly off the Delta.

Production

By far the most productive region, and area where most of the fishery concentrates, is around the Mississippi Delta, with approximately 1/3 to 2/5 of the total production taken on the eastern side. The total U. S. landings for 1972 were 4.7 billion pounds valued at a record $703.6 million at the ex-vessel level (Wheeland, 1972). The latest production figures (1970-72) show the Gulf of Mexico landings have grown to 40% of the U. S. total by volume and 30% by value. This is compared to the figures of 1930 when the Gulf production was a mere 5% and 4% in volume and value respectively. (Fig. 1). As a corollary on a world-wide basis the productivity of the Gulf, specifically the northern area, is considered second only to that of the Peruvian coast. From our present knowledge about the Gulf resources, it is expected that this growth will continue.

With respect to the fish landings and relative value in the Gulf states, Figures 2 and 3, which follow, are self-explanatory.

Since only a small portion of the Louisiana landings originate east of the Delta, we shall assume that the subject area only includes Mississippi, Alabama, and Texas. Note that combined landings and value of these three states are approximately 28% and 34%, respectively, of the Gulf total.

On the producing and processing side, records show that until 1900 the entire Gulf fishing fleet had less than 400 vessels and 5,000-6,000 smaller boats. By 1967, the fleet contained nearly 4,000 vessels and over 10,000 small boats manned by more than 20,000 fishermen. Fish wholesaling and processing facilities now number over 800 and support more than 13,000 employees (Thompson and Arnold, 1971). In 1971, there were 1,200 vessels, 2,800 motor boats, and 7,000 fishermen operating in the three eastern states. Except where noted, the data refer to the subject area.

Of the species not taken commercially in the Gulf the eight leading ones, grouped by fishery are: 1. Shrimp, 2. Menhaden, 3. Red Snapper and Grouper, 4. Oyster, 5. Mullet, 6. Industrial Bottomfish, 7. Spanish and King Mackerel, and 8. Blue Crab. A brief description and status of each fishery follows:

1. The shrimp fishery in this area includes pink, brown, and white shrimp. These are taken exclusively with trawls, in depths ranging from 1 to 50 fathoms. The fishery is the most valuable in the region--in 1972 the total landings in the three states were 48 million pounds valued at 27 million dollars. In this area the Tortugas grounds are the most productive, pink shrimp being the predominant species. Based on the fairly uniform landings in the last few years, the fishery has reached a plateau with questionable room for expansion, with the exception of the central west Florida "bad" grounds.

2. The menhaden fishery is confined exclusively to the Pascagoula-Moss Point, Mississippi area and Chandeleur. Almost the entire catch is taken in the Mississippi Sounds. The total production in 1972 was about 160 million pounds with a value of 3 million dollars. The catch from there is used for the manufacture of fish meal. Florida landed close to 1 million pounds, primarily utilized for bait. The present fishery, unless expanded into other areas, shows little room for expansion. Stocks exist in the Alabama to Apalachee Bay which would be utilized should regulations permit.

3. Red snapper and grouper are taken offshore with hook and line in depths of 30 to 100 fathoms. The production in the last few years has been over 6 million dollars. Owing to additional foreign and sport fishing, probability of fishery expansion in the traditional grounds looks dim.

4. The oyster industry has declined in importance in Mississippi and Alabama but remains stable in Florida. The production in 1972 was close to 5 million pounds of meats valued at 2.7 million dollars, down from previous years. This shellfish is taken, for the most part, by tonging.

5. The mullet fishery centers in Florida (Anonymous, 1972); some are taken in Mississippi and Alabama. The annual production has been on the increase; the 1972 landings totaled over 30 million pounds with a value close to 3 million. The principal capture gear are gill and trammel nets. An increase in production of this species is imminent because of expanded markets--local and foreign.

6. The industrial bottomfish trawl fishery operates from the ports of Biloxi and Pascagoula. The vessels are modified shrimp trawlers utilizing larger and heavier gear. Approximately 100 million pounds are landed annually (Wise, 1972). The commercial catch includes about 175 species. The dominant species in this resource are the drums (Sciaenidae)--croaker, seatrout, spot. A greater use of the resource is expected soon with the introduction of improved systems for collecting and keeping the incidental bottomfish taken by shrimp vessels.

7. The Spanish and king mackerel fishery is based primarily in central and southwest Florida. The 1972 landings were 9 million pounds (8 million from the Florida west coast) with a value of 1.1 million. Almost the entire catch is taken with gill nets. Expansion of the fishery is possible in two general respects: by increased effort in Mississippi and Alabama, and by permitting the use of more efficient gear such as purse seines.

8. Blue crab is another important fishery with a landed volume of close to 25 million pounds and value in excess of 2 million dollars. Crab pot and trot lines are the gear more commonly used. Increased production prospects are good but dependent on availability of processing plant labor.

Underused and Latent Resources

Exploratory fishing and other oceanic surveys of the southeastern area have indicated that the shelf of this region supports numerous latent resources. Bear in mind that the estimates of these stocks are rough and need to be refined through further survey assessment work. These resources will be discussed in groups with or without taxonomic relationship but within similar environmental parameters.

Large Pelagic Fishes
(Billfish, Dolphin, Mackerel, Shark)

The Gulf supports a sizable billfish population of which little is known. Work currently being conducted on life histories indicates adults may migrate to spawn in the southern Gulf and Caribbean areas. Though they have little present commercial value, they do have a high value to sport fishermen, both on the east coast and in the Gulf. High mercury levels found in swordfish and in some of the marlins tend to discourage U. S. commercial exploitation but are not apparently affecting the recreational catch. At this time, there is no estimate of the sustainable yield.

Mackerel

Two mackerels are found in the southeastern area: the king, *Scomberomorus cavalla*, and the Spanish, *S. maculatus*. Both are migratory and, at present, commercial fisheries exist for both species. The bulk of the commercial catches occurs within 12 miles but the migratory behavior of these animals could increase their vulnerability to offshore fishing. No estimate of the Spanish mackerel population in the Gulf is available; however, a major portion of these stocks is assumed to be found in the subject area.

Sharks

Several species of sharks (i.e., blackfin, silky, dusky, white tip, tiger, hammerhead) inhabit the Gulf area in seemingly high abundance. The Mississippi River Delta and other commercial fishing areas are particularly productive due, in part, to the shrimp fisheries scrap discards in that area. The standing stock of sharks in the western Atlantic has been estimated by Bullis and Carpenter, 1968,and Bullis, Carpenter, and Roithmayr, 1971, at 400 million pounds, a large portion of this in the Gulf.

Black, Skipjack, and Little Tuna

These species abound in the subject area. Little tuna prefers inshore areas in the mixing zone of clear and murky water while the blackfin and skipjack prefer clear waters over the edge of the Continental Shelf. Commercial harvest of little tuna is 600 tons per year and practically non-existent for blackfin and skipjack.

Coastal Pelagic Fishes

This group refers to small, surface, and midwater schooling fishes of the herring, sardine, and anchovy groups. Included are some jacks, butterfish, and bumpers. The principal commercial coastal pelagic species in the south Atlantic and Gulf is the menhaden, described earlier.

Other coastal pelagic species occurring in the eastern Gulf are thread herring, Spanish sardine, scad, round herring, cigar minnows, and anchovy, which are exploited but on a very limited basis. Most occur inside of 10 fathoms but seasonal shifts in abundance indicate the stocks range seaward to 12 miles. The most abundant may be thread herring for which a temporary commercial fishery existed in Florida waters in the late 1960's. Estimates of the latent potential for thread herring in the Gulf of Mexico are 2 billion pounds with the greatest abundance off Florida.

Some of these coastal pelagic species such as menhaden and thread herring are readily taken by purse seine gear but others such as sardine, round herrings, and anchovy are difficult to catch. New and innovative harvesting systems would be required to successfully harvest the bulk of the coastal pelagic resources in the Gulf.

Bottomfish

This group of finfishes, comprising some 175 species, constitutes perhaps the second largest resource, by volume, of the southeastern United States. The dominant group within the resource are the drums (Sciaenidae) --croaker, spot, seatrout; however, other species such as sparids and sea catfish are major constituents (Roithmayr, 1965).

Bottomfish occur on the Continental Shelf, on mud or sand bottoms, generally being found shoreward of 30 fathoms but often reaching sizable densities outside this depth. Most are estuarine-dependent during part of their life cycle.

In the early 1960's, approximately two-thirds of the resource was harvested within the 12-mile zone; however, recent data indicate that only 55 per cent of the catch came from within 12 miles, demonstrating a trend to larger vessels having a wider operating range. A large volume of industrial bottomfish is taken during shrimping operations in the south Atlantic and Gulf and discarded overboard. Estimates of this loss range from 4 pounds to 15 pounds of discard per pound of shrimp caught. If these ratios are referenced with total shrimp landings in the eastern Gulf, the annual volume of discarded bottomfish could be 200 to 800 million pounds.

Reef Fishes
(Snapper, Grouper)

Snappers, of which approximately 12 species are used in the commercial fishery, and several species of grouper, constitute a group of fishes inhabiting reef and rough-bottom environments through the south Atlantic, Gulf, and Caribbean regions. The principal species in the fishery is the red snapper which, until recent years, was produced primarily from the Gulf.

Little information is available on the life history and stocks of these fishes and only crude estimates of the total standing stock have been made with no estimates of maximum sustainable yield yet available.

Establishment of oil rigs in the Gulf of Mexico has created new fishing "grounds" but it has also brought commercial fishing into direct competition with recreational fishing.

Resource Surveys By NMFS, SEFC

Resource assessment and exploratory fishing activities have been carried out in a formalized fashion by NMFS and its predecessor, BCF, since 1950. Although the marine areas under our purview cover the western Atlantic from Cape Hatteras to Brazil including the Gulf and Caribbean, much work was undertaken in the subject area. The main objectives of the program were to obtain information on the current and potential fishery resources of the Gulf of Mexico, so as to meet present and future industry needs, and to compile basic faunal lists of the area.

Most of the survey work has been conducted with conventional or modified commercial fishing gear, specially fitted or designed vessels, such as the OREGON, OREGON II, SILVER BAY, GEORGE M. BOWERS, etc. Although the activities centered on gaining living resource information, environmental data were also collected. The gear used included fish and shrimp trawls, longlines, gill nets, lift net, midwater trawls, trolling lines, snapper reels, etc.

The following tabulation (Table 1), compiled from the ADP bank housed in the Pascagoula Laboratory, summarizes part of these survey activities, from 1950 to the present. Fish spotter flights and remote sensing observations which were conducted for several years, are not included. In this tabulation the Zones 5 and 6 refer to the regional faunal zone division as shown in the map (Fig. 6).

Directly related to the resources of the subject area, we initiated a Groundfish Program in 1973. The objectives of this Program are to evaluate the industrial and foodfish groundfish fishery in the northern Gulf and provide information in availability, abundance, and status of the resource. The specific work area extends from Apalachicola, Florida to Galveston, Texas; the depth range is from 10 to 50 fathoms. Should the need occur this Program could be expanded to include the entire subject area (Juhl, et al., 1973).

Special Topics

With respect to commercial fisheries, we should identify special aspects that have a direct bearing on the fishery resources, not only of the subject area but also of the entire Gulf.

It is apparent that many of the important stocks presently harvested are reaching or have reached a maximum yield. Continued growth of the industry, therefore, will have to depend on underused and latent stocks, and more effective use of those harvested now. The present increased pressure on the shrimp stocks, owing to greater competition and higher prices, will undoubtedly aggravate the fish discard situation. This is because more fishing will be done in marginal areas where the ratio of shrimp to fish may be higher than normal.

In 1973 the price of fish meal reached an all-time high (rising from $200 to $640 per ton in foreign markets) as a consequence of the failure of the anchoveta fishery in Peru. The scarcity of meal not only drove up prices of existing inventories and related commodities but also uncovered the dependency of the U. S. on foreign imports and the need for alternate sources. Menhaden processors are now looking into the possibility of using groundfish to supplement their production. This will undoubtedly lead to greater pressure on the extant resources. It is imperative to provide the necessary resource assessment and short-range prediction information for effective utilization and management.

In contrast to northern fishery resources, the Gulf species are relatively short-lived and have a high turnover. The conventional methods of determining population estimates and strengths are not valid. Under this situation in the Gulf there is a need for developing short-range stock prediction capabilities.

In my opening words, I mentioned that the production capability of the Gulf was second only to Peru. The high productivity is directly related to the vast quantities of nutrients pouring into the coastal waters by drainage from the Mississippi River, other tributaries, upwelling along shores, and the nature of the vast existing estuarine habitats and marsh lands. It has also been stated by many researchers that over 95% of the species comprising the Gulf fish catch are dependent on this coastal environment. It is essential, therefore, that this environment be maintained and enhanced if continued high fishery production capability is expected.

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Table 1.

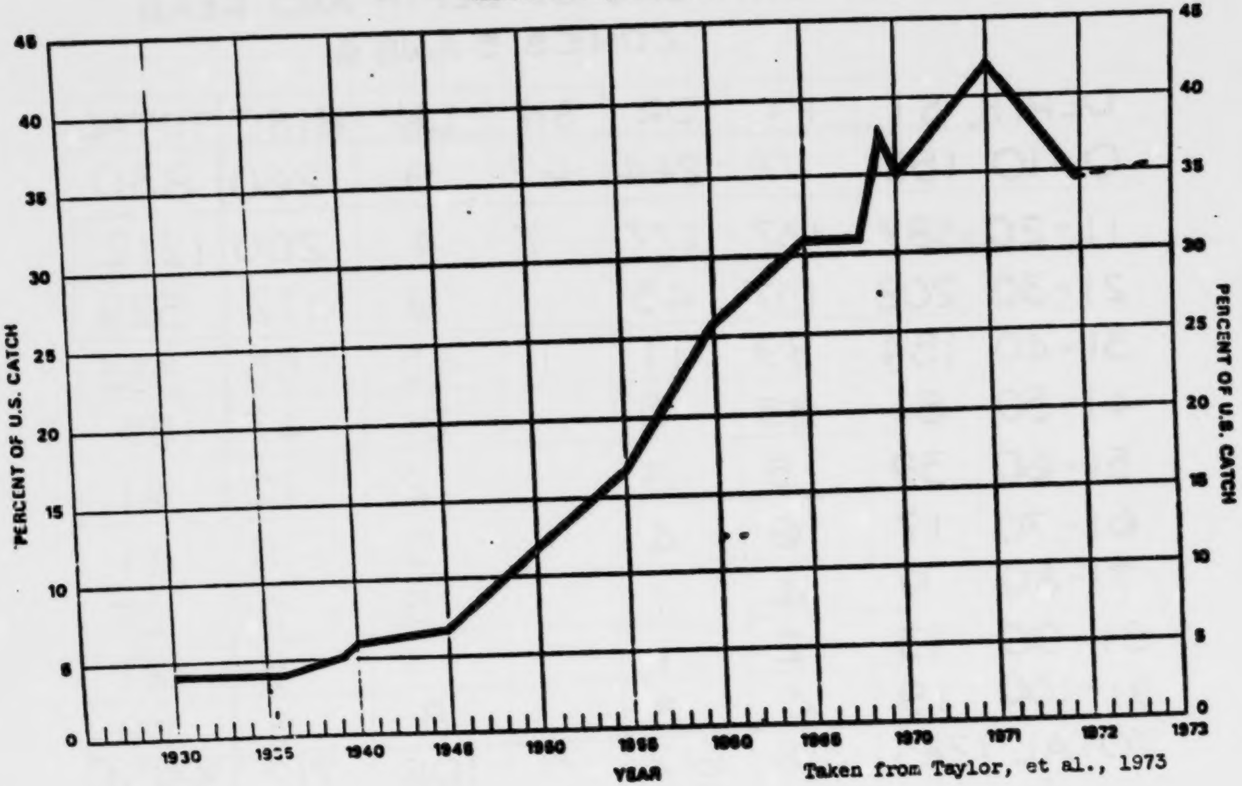
NUMBER OF STATIONS BY DEPTH AND GEAR
ZONES 5 AND 6

DEPTH	ST	FT	DR	SN	LN	MISC	TOTAL
0-10	158	77	264	62	9	260	830
11-20	587	137	277	7	4	200	1212
21-30	208	157	43		9	112	529
31-40	154	89	11	1	45	55	355
41-50	81	35	5		21	47	189
51-60	39	5	3		2	12	61
61-70	17	6	4	1	5	8	41
71-80	9	4	1		5	8	27
81-90	13	2	1			5	21
91-100	19	4	3		8	5	39
TOTAL	1285	516	612	71	108	712	3304

ST = shrimp trawl; FT = fish trawl; DR = dredge; SN = seine; LN = longline; Misc. = miscellaneous.

Figure 1

Gulf State Fisheries in Percent of Total U.S. Catch
Various Years, 1930-1971



Taken from Taylor, et al., 1973

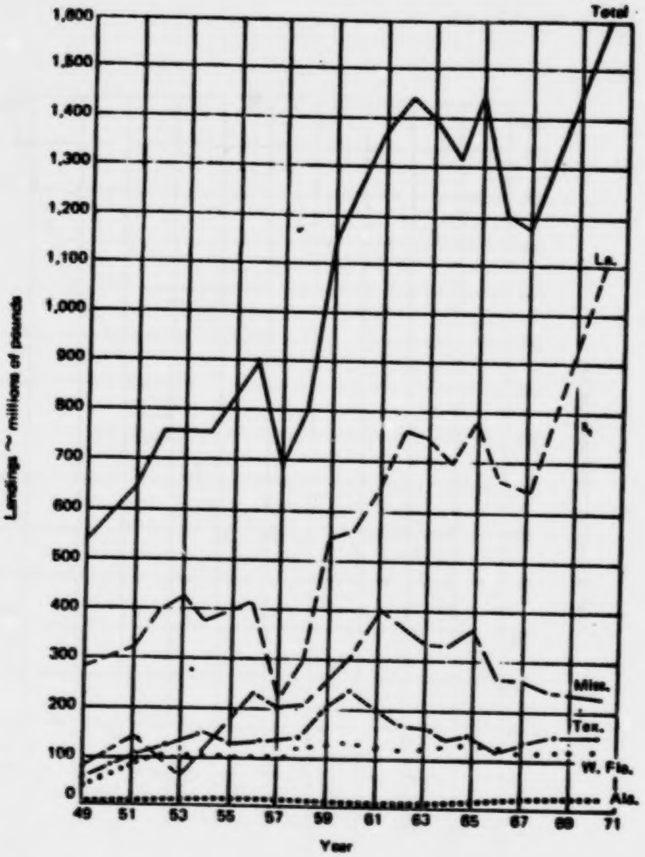


Figure 2 **Gulf Landings, All Species (1948-1970)**

Taken from Taylor et al., 1973

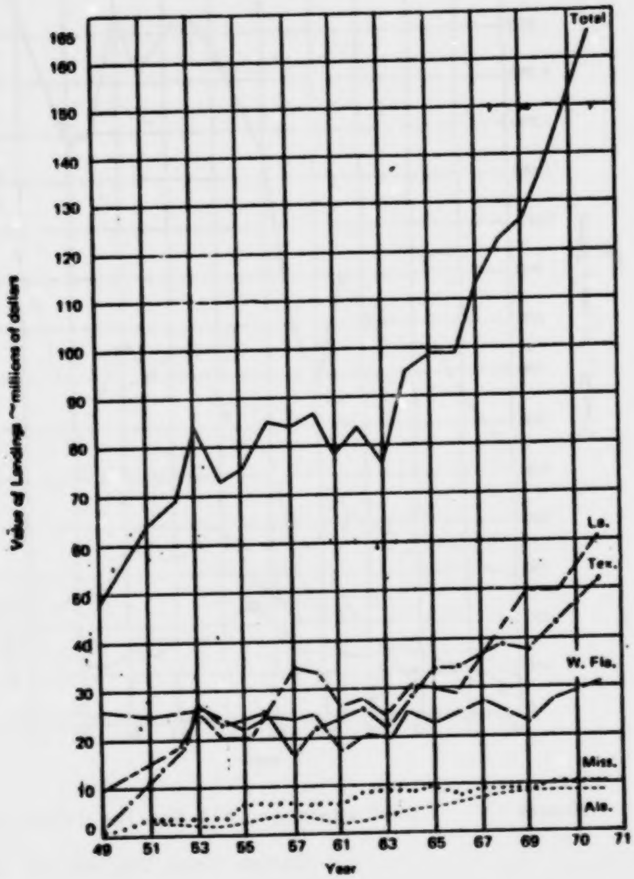


Figure 3 Value of Gulf Landings (1948-1970)

Reproduced from
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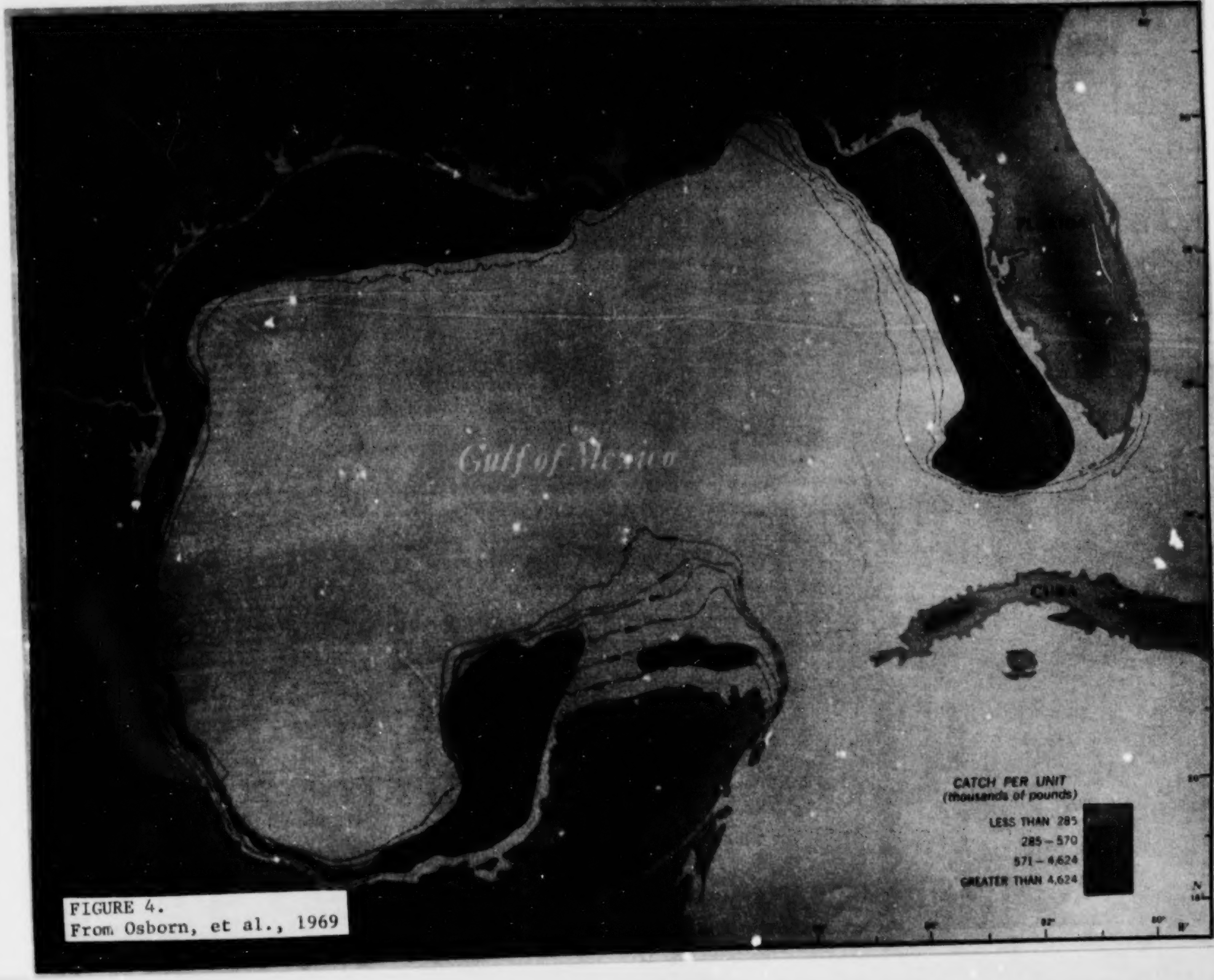

Gulf of Mexico
FLORIDA
CUBA
CATCH PER UNIT
(thousands of pounds)
LESS THAN 285
285 – 570
571 – 4,624
GREATER THAN 4,624

FIGURE 4.
From Osborn, et al., 1969

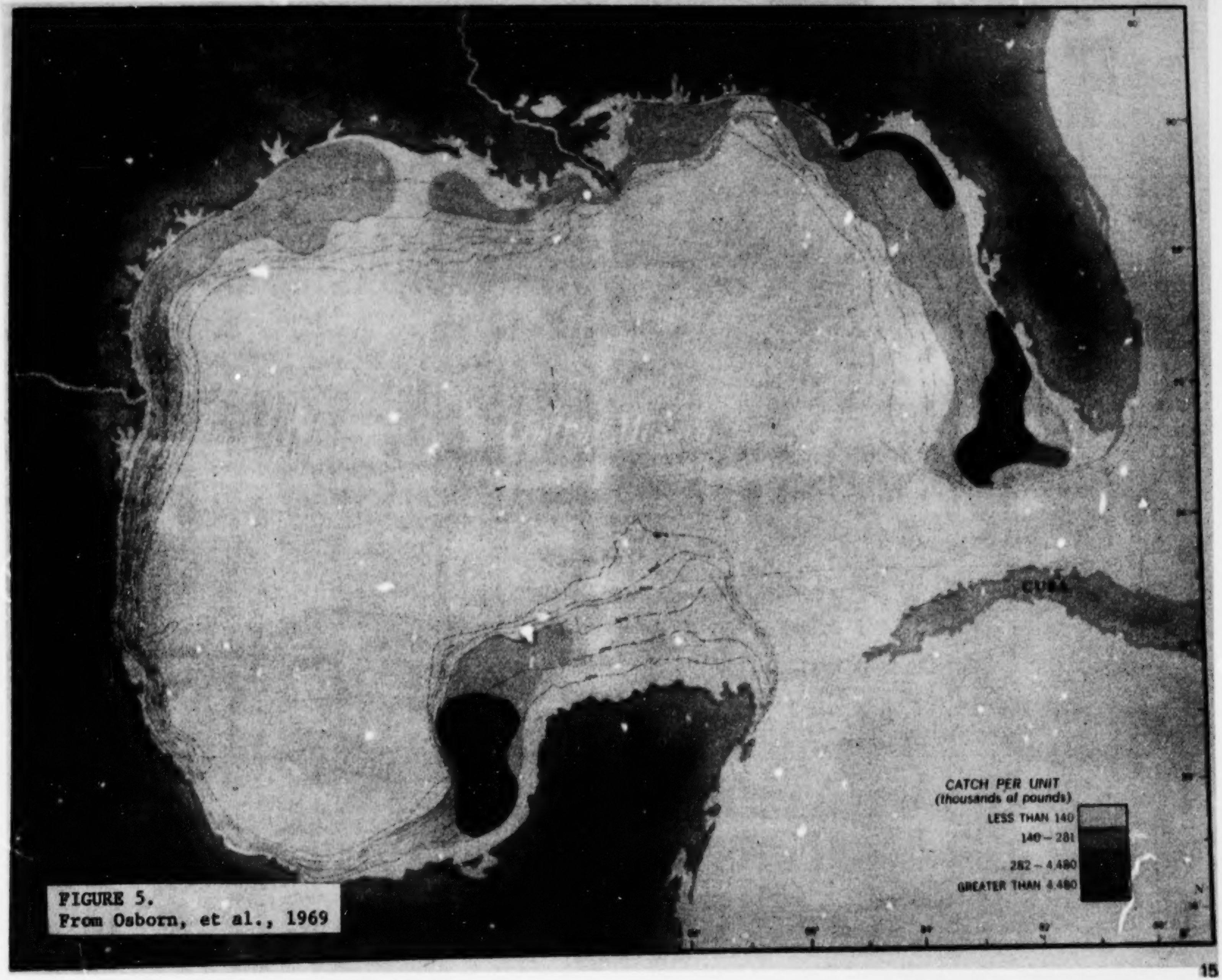
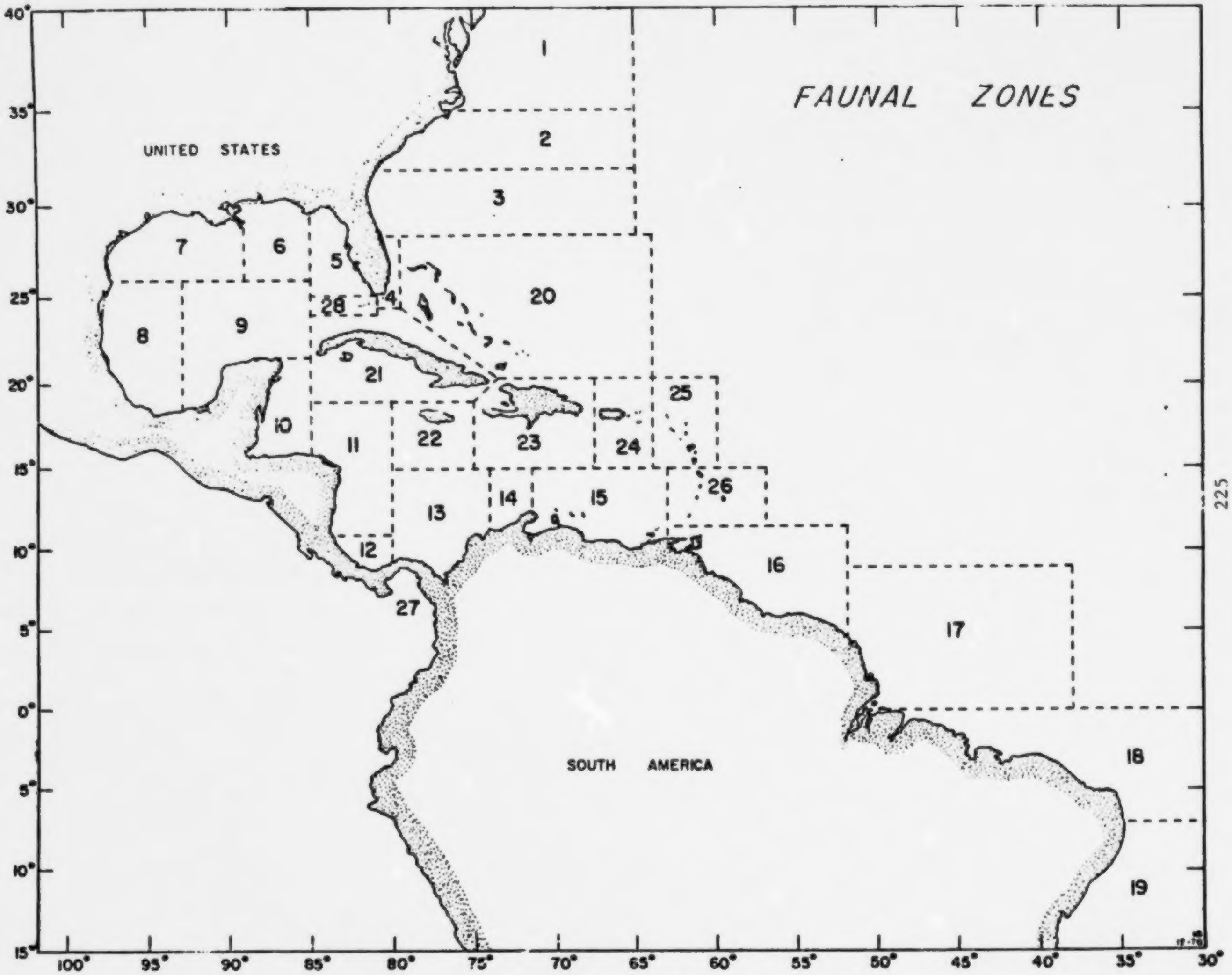

CUBA
CATCH PER UNIT
(thousands of pounds)
LESS THAN 140
140 – 281
282 – 4,480
GREATER THAN 4,480
N

FIGURE 5.
From Osborn, et al., 1969

FIGURE 6.


FAUNAL ZONES
UNITED STATES
SOUTH AMERICA
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35°
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Observations on the Florida Middle Ground Through the Use of Open-Circuit SCUBA

Thomas S. Hopkins
University of West Florida
Pensacola, Florida

As a prelude to this presentation, I wish to acknowledge the generous support of two cruises aboard the Florida State University (FSU) research vessel, R/V TURSIOPS, and three cruises aboard the research vessels, R/V DAN BRAMAN and BELLOWS, leased by the State University System of Florida Institute of Oceanography (SUSIO). I have been able cooperatively to make some qualitative observations on the flora and fauna of the Florida Middle Grounds (FMG) at 28°35N' and 084°16'W. To date we have collected: data on fish species and behavior through L. Ogren, National Marine Fisheries Service (NMFS), Panama City, S. Bortone, University of West Florida (UWF), and C. Combs, SUSIO; data on sponges by R. Yockey at the University of Florida (UF) working under F. Maturo; data on macro-molluscs by J. McDonald, UWF; data on algae by J. Dyer, University of South Florida (USF) (given to H. Humm, USF), and S. Gay and D. Grimm, UWF, (given to P. Winter, UWF). My own interests have been the reef-building cnidarian fauna, the echinoderm fauna, and the reef-face microclimate and associated zooplankters. My principal research associates have been A. W. Blizzard, R. Mattlin, D. L. Rieck, and K. Shaw, all from UWF. We have several manuscripts from this work in progress.

Turning to the Cnidaria, Millepora sp. is clearly the prevalent cnidarian hydrozoan. The other hydrozoan fauna have not been worked up. We believe there are about 8 kinds of alcyonarians, 8 madreporarians, 2 actinarians, and one zooantherian fairly common to our study area.

The echinoderm fauna is dominated by the basket star, Astrophyton, a brittle star, Ophiothrix, and the echinoid, Diadema. Coscinasterias, an asteroid, is an infrequent reef dweller. The sand-rubble area immediately adjacent to the reef has yielded the asteroids, Echinaster, Oreaster and Narcissia, and the echinoids, Meoma, Plagiobrissus and Eucidaris. Uncollected burrowing ophiuroids are present in this area. Crinoids and holothurians are conspicuously absent in both areas.

The pictures used by Mr. L. Ogren today in his joint presentation with Mr. G. Smith, were taken during a R/V DAN BRAMAN cruise in late summer, 1971. The reef-rubble adjacent to the reef lies in 120-130'. The base of the reef starts forming at 115-120' and in some places climbs very steeply to 90'. Very steep breaks of this kind alternate with relatively even slopes with a 1' in 10' grade. Our principal study

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area is an area of steep relief (1' in 2' average).

Although I will not describe the study area in specific detail, I would like to describe the area with reference to faunal indicators. It should be understood that these named zones are only a point to work from in understanding today's slides and in ensuing Workshop discussions; other investigators may have entirely disparate views. The first area is the sand-rubble area which does not at this time have a cnidarian indicator assigned. In the slides, you will see a singularly interesting alcyonarian which I have not been able to recognize in Bayer's (1961) treatise on octocorallians. It inhabits this area, along with scattered heads of *Millepora*. The second zone, the area of steep relief, 115' to 95', is a *Millepora*-*Porites*-*Oculina* zone as these are the dominant cnidarian structures. The area 95-80' is almost entirely dominated by *Millepora* in a zone about 5-10 meters wide. The *Millepora* zone ends rather abruptly with what I shall call the *Muricea*-*Dichocoenia* zone. This area is named for its principal occupants, the octocorallian tentatively identified as *Muricea* and the plate-forming madreporarian tentatively identified as *Dichocoenia*. This zone occupies the area 5-10 meters immediately above the *Millepora* zone. A fourth zone should be established, for the dominant octocorallian has changed even though the dominant madreporarian has not. Bathymetrically, this reef area may rise to as much as 80' and form a slightly undulating plateau with "washouts" as deep as 3-4'.

For the sake of today's meeting a comparison to the West Flower Garden Bank (WFGB) and its coralline flora-fauna as reported by Edwards (1971) may be worthwhile. After studying Edwards' report, I conclude that not only are the areas dissimilar geologically, they are dissimilar floristically and faunistically. For example, Edwards reports a scarcity of the coralline alga, *Halimeda*; however, *Halimeda* is quite abundant at FMG. Faunistically the dominant encrusting madreporarians at WFGB are *Diploria* and two species of *Montastrea*, whereas, the dominant encrusting forms at FMG are tentatively identified as *Dichocoenia* and *Stephanocoenia*. Edwards mentions *Millepora* without significance, and it is very significant at FMG.

A comparison of FMG ichthyofauna to WFGB icthyofauna may prove interesting and should be developed as quickly as possible.

I apologize for not comparing the FMG cnidarian fauna to "Hourglass" collections, but the information reported here was only formulated as a result of my most recent visit to the FMG in January of this year. A comparison will be made in press, and perhaps Bill Lyons can comment today, since he has worked on that material.

Comments on the Nature of the Florida Middle Ground Reef Ichthyofauna

Gregory B. Smith
Florida Department of Natural Resources
Marine Research Laboratory
St. Petersburg, Florida

Larry H. Ogren
NOAA/National Marine Fisheries Service
Gulf Coastal Fisheries Center
Panama City, Florida

The Florida Middle Ground is an extensive offshore area of rugged submarine terrain located along the outer West Florida Shelf (28° 11' to 28° 45' N.; 84° 00' to 84° 25' W.) approximately 95 miles south of the Florida northwest coast and 100 miles northwest of Tampa. The entire region is characterized by steep-profiled escarpments and prominences which may precipitously rise 35 to 50 feet from the surrounding bottom. Depths throughout the area vary between 78 and 138 feet. Brooks (1962) has suggested that much of the Middle Ground topography is due to underlying Pleistocene reefs which flourished during the last interglacial, the Sangamon.

Historically, the Florida Middle Ground has been one of the most productive and consistently fished "reef areas" in the Gulf of Mexico. As early as 1883, commercial vessels sailed from Pensacola to fish for red snapper (Lutjanus campechanus) at the Florida Middle Ground (Futch and Torpey, 1966). In spite of heavy and continuous fishing pressure, the Middle Ground still remains a productive source of both commercial and sport fishes (Austin, 1970). Presently, most of the commercial grouper-snapper fishing effort on the West Florida Shelf is centered at the Middle Ground, Elbow and adjacent reef fisheries. In addition, several new partyboats capable of cruising 20 to 30 knots leave daily from Clearwater and St. Petersburg to fish the Middle Ground and other deep-water reefs on the outer West Florida Shelf. More conventional partyboats and sportsfishing vessels periodically depart from Panama City, Tarpon Springs, Dunedin, Clearwater, St. Petersburg and Sarasota. These feature 2 or 3 day fishing trips to the Middle Ground. Consequently the Middle Ground and nearby reef fisheries represent a sizable source of economy to the state of Florida. In 1971, 6,356,360 pounds of groupers with a dockside value of $1,272,475, and 5,800,171 pounds of snappers valued at $2,941,717 were brought into ports along Florida's west coast (Johnson, 1972). Although a substantial portion of these landings reflect the success of the Campeche (Mexico) fishery, a significant faction also represents production on the West Florida Shelf. When values accrued at steps from landing, processing, and retailing the catch are added to these figures paid to the fishermen, the monetary significance of the West Florida Shelf bottom fishery becomes even more impressive.

Certain physiographic, hydrological and biological features have allowed the development of a rich and abundant biota, dominated by tropical elements, at the Middle Ground. "Reef" crests are covered with invertebrates and benthic algae typical of deepwater West Indian reefs (Austin, 1970). Brooks (1962) postulated that the presence of scleractinian and alcyonarian corals, hydrocorals and coralline algae were comparable to those of reefs in the Florida Keys. Reef fishes are also largely characteristic of more southerly regions within Caribbean and West Indian faunal provinces. The occurrence of numerous fishes which represent distributional records (e.g. eastern Gulf, northward range extension, etc.) emphasize the ichthyofaunal distinctiveness of the Middle Ground region.

Buffered environmental conditions associated with offshore distance and moderating current patterns confer a certain stability to the Middle Ground region and allow for successful occupation by numerous stenotolerant tropical reef fishes. Because of certain conditions associated with its offshore location, the Middle Ground may be considered primarily an insular rather than continental environment. Consequently, clear oceanic waters, shallow reef crests, steep-profiled bottom topography and carbonate sediments at the Middle Ground are attractive to insular (West Indian) reef fishes which are either rare or absent at other areas of the West Florida Shelf.

The relative constancy of physical-chemical characteristics has probably allowed the evolution of a predominately biologically accommodated community at the Middle Ground. In the absence of certain environmental limiting factors, biological stresses are ultimately resolved through the evolution of biological accommodation resulting in "stable, complex and buffered assemblages.... characterized by a large number of stenotopic species" (Sanders, 1968). Through biological accommodation, certain interspecific relationships considerably more complex than simple predator-prey interactions have evolved. For example, the occurrence and conspicuous abundance of cleaning symbionts (organisms which remove ectoparasites and necrotic tissue from the bodies of certain host fishes) such as the neon goby (*Gobiosoma oceanops*), juvenile bluehead wrasse (*Thalassoma bifasciatum*), banded coral shrimp (*Stenopus hispidus*) and cleaner shrimp of the genus *Periclimenes* undoubtedly affect the overall complexion of the Florida Middle Ground ichthyofauna. Certain investigators (Limbaugh, 1961; Mahnken, 1972) have speculated that the diversity of coral reef fish assemblages may be profoundly influenced by the presence of cleaning organisms and Feder (1966) asserted that many good fishing grounds are such primarily because they are cleaning stations.

Another feature which permits a greater species diversity and abundance at the Florida Middle Ground is the physiographic heterogeneity of the environment. Unlike most other areas of the West Florida Shelf, the Middle Ground is characterized by high relief ledges and rocky outcroppings which afford greater surface area, available shelter and microhabitats for more kinds and numbers of fishes.

The Florida Middle Ground receives ichthyofaunal contributions from both inshore, shallow reef communities and offshore, deep reef communities because of its proximity to the outer West Florida Shelf and tremendous depth differentials. This "edge effect" may partially account for the increased variety of the Middle Ground ichthyofauna. The Middle Ground is a zoogeographically transitional region in that it receives warm-temperate, eurythermic, insular tropical (West Indian), continental tropical (Caribbean) and Gulf of Mexico endemic ichthyofaunal elements. However, a qualitative comparison of the Middle Ground ichthyofauna with those of other reefal sites in the Gulf of Mexico and western Atlantic indicates both greater intra-Gulf homogeneity and Caribbean-West Indian affinity than previously suspected for these populations.

Dynamic hydrographic conditions favor seasonal upwelling and associated high primary productivity along the seaward edge of the Middle Ground. Zooplankton volumes comparable to concentrations detected in known regions of upwelling off Peru, southern California and west Africa have been documented at the Middle Ground (Austin, 1970). This situation obviously contributes to the tremendous populations of plankton-feeding fishes (primarily Chromis and Apogon) at the Middle Ground, a condition not nearly so apparent at most other reef sites on the West Florida Shelf. These planktivorous fishes are significant importers of food into the reef community and permit a greater diversity in species composition (Starck and Davis, 1966). A definite correlation is therefore proposed between water column productivity, abundance of planktivorous fishes and the overall dominance-diversity structure of the Middle Ground ichthyofauna.

In summary, a fortuitous combination of physical, chemical and biological features has contributed to the development of a Middle Ground reef ichthyofauna which is quite distinctive (both qualitatively and quantitatively) from that of other reef areas on the West Florida Shelf. There exists a growing concern that increased bottom turbidities and sedimentation which might be generated during exploratory oil-drilling operations could seriously jeopardize the ecology of a productive reef community such as exists at the Middle Ground. Because the water column overlying the Middle Ground is frequently stratified, it is feared that increased turbidities below the thermocline due to the release of drilling muds, drill cuttings and physical disruption of the substrate might effectively reduce light penetration below the critical limit necessary to sustain the coral (hermatypic) and algal assemblages so characteristic of the Middle Ground region. It is a unique situation which has not previously been encountered in other areas of the Gulf where oil-drilling operations are currently in progress. These latter regions are dominated by warm-temperate, soft bottom faunas which exhibit rather broad tolerances to environmental parameters. The tropical reef community at the Florida Middle Ground, however, would be many times more sensitive to environmental perturbations often affiliated with oil exploitation and production.

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Chemical Oceanography

Inorganic Aspects of OCS Petroleum Operations

Eugene F. Corcoran
Rosenstiel School of Marine and Atmospheric Science
University of Miami
Miami, Florida

Kent A. Fanning
Department of Marine Science
University of South Florida
St. Petersburg, Florida

Probably the best-documented chemical aspect of the nearshore waters of the eastern Gulf of Mexico has been the study of the distribution and concentration of nutrients found there. Of the nutrients, phosphorus has by far received the greatest attention. One of the reasons for this great interest in phosphorus measurement has been its possible role in "red tide" outbreaks (Ketchum and Keen, 1948); another has been the nearshore phosphate deposits. Somewhat less attention has been given to the study of the nitrogen and silicon compounds. Trace metals and organics have been the least studied. While offshore oceanic waters receive nutrients from the atmosphere, most of the nutrients in the coastal waters come from weathering, industrial wastes, and sewage through river runoff or dumpings.

Phosphorus

Odum (1953) did a study on the phosphorus concentrations in Florida waters and found that streams flowing through phosphate beds had increased concentrations of phosphorus. An example of this is shown in a later study done by the U.S. Department of the Interior (USDI), which shows the Alafia River (Figure 1) to be a source of phosphates in Tampa Bay. The highest phosphate values reported for the Alafia River were 9.65mg/liter (about 311 µg atoms/liter) decreasing to 1.65 mg/L (or about 53 µg at/L) at the mouth of the bay. These concentrations are from 50 to 300 times the levels necessary to support accelerated eutrophication, the premature aging of an estuary. According to the report, 43,470 pounds of PO_4-P are discharged daily from the Alafia River and another 8,810 pounds of phosphate enters through industrial dumping from U.S. Phosphoric Products. While there are a number of phosphate investigations on the rivers and estuaries of South Florida, most investigations stop when the waters enter the Gulf of Mexico. Graham et al. (1954) extended their measurements out to the depth of 50 meters (100 fathoms) and showed that phosphate concentration dropped two orders of magnitude from the Peace River to

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offshore 192 kilometers (120 miles). Dragovich et al. (1968), in their studies of phosphates showed a similar drop from river to bay to nearshore Gulf of Mexico. Figure 2 shows the phosphate values found by Dragovich along with those for iron and chlorophyll. Although the concentrations reported by Dragovich are not as high as those from the USDI study, some of the river values are substantial. For example, the phosphate concentrations in the Alafia River and station 8 of the Peace River are 29 and 30 µg at/L respectively (Odum had reported an average of 167.7 µg at/L). However, in each case the concentration had dropped to 0.6 µg at P/L at a distance of 37 kilometers offshore.

Because an early suggestion by Ketchum and Keen in 1948 indicated a possible role of phosphate in "red tide" outbreaks, the Bureau of Commercial Fisheries (BCF) did an extensive study of the waters entering the Gulf of Mexico from Tampa Bay and Charlotte Harbor. These data can be found in the bureau's annual reports from the middle 1950s to the early 1960s.

Curl obtained data from Odum and Grice to summarize the information on the phosphorus concentrations found in west Florida coastal waters. His summary included the rivers and estuaries from Pensacola to the Florida Keys and showed the Peace River, with an average of 167.70 µg at/L, to be the highest. The estuaries and bays had concentrations between 1 and 3 µg at/L, and our measurements taken during the first Eastern Gulf of Mexico study (EGMEX I) showed the coastal waters from Pensacola to Apalachicola to have a phosphate concentration between 0.1 and 0.2 µg at/L.

Like Tampa Bay in the east, the Mississippi River in the northwest is a great phosphorus contributor. Figure 3 shows the results of a study published by Alberts in 1970. Alberts gave his results in ppm, but I have taken the liberty to convert these values to ug at/L for comparison. Here we see that at 189 kilometers (118 miles) above the Head of the Passes the phosphate concentration is just above 4.13 µg at/L and is about 0.48 µg at/L in the offshore waters. Our values, taken in the spring of 1970, agree with those of Alberts. Our measurements did not extend quite as far north in the river and varied from 3.99 µg at P/L up river to 0.47 µg at P/L off Southwest Pass. According to Alberts the Gulf of Mexico receives 1.4 x 10^6 mg P/sec from the Mississippi River and 0.5 x 10^6 mg P/sec from the Peace River.

Until recently, studies on phosphate concentrations have been concerned primarily with the rivers and bays as opposed to the coastal and shelf areas. Berberian has just completed a study in which he analyzed samples from all depths taken from 191 grid stations in the eastern Gulf of Mexico. These data are being used in his dissertation and may possibly be used as a baseline for further study.

Nitrogen

The distribution and concentration of nitrogenous nutrients in the coastal and shelf waters of the eastern Gulf of Mexico are not nearly so well documented as for phosphate. Like phosphorus, however, the most extensive and comprehensive studies have been done for rivers and estuaries. In fact many of the investigators that made phosphate observations also measured the presence of one or more forms of nitrogen. Unlike phosphorus, which is measured as a phosphate, there are three chemical forms of nitrogen that are usually considered nutrients. These are ammonia, nitrite, and nitrate. Another significant difference is in the methods of phosphate measurement as opposed to the methods of determination of the nitrogen compound. Most investigators have used some form of "Molybdenum Blue" in their phosphate determinations and so the results are somewhat comparable. Of the nitrogen compounds the nitrite measurements probably have the most comparable results since most investigators measure photometrically the highly colored azo compound. The nitrate is probably the most determined of the three and is done by reducing the nitrate to nitrite. It is this reduction process that causes variability in results. Undoubtedly one of the most, if not the most, important of the nitrogenous nutrients is ammonia, which probably has the greatest variability in results. Ammonia has been determined from Nesslerization to filtration, and Hach kit to Autoanalyzer and the results show it.

But in spite of the differences in measurement, there have been some extensive and comprehensive studies of these nitrogenous nutrients in the eastern Gulf of Mexico. Freiberger (1972) studies all three forms of nitrogen in the southernmost parts of Florida. He showed ammonia to be the most dominant species with values of 0.01 to 25 mg NH_3/L depending on the area and the season of the year. During the dry season he reported an average 1.3 mg/L (93 µg at/L) in the Everglades, which he attributed to the activities of the birds and animals. Freiberger's studies did not extend into the Gulf of Mexico, but Dragovich et al. (1963) studied the coastal area off Naples, Florida. Their measurements of nitrate-nitrite-nitrogen varied from 0.0 µg at/L to 4.4 µg at/L with an average of 0.7 µg at/L. Another offshore determination of nitrite and nitrate was done by Franks et al. as a part of a study of the nektonic and benthic fauna in the shallow waters off Mississippi. Their values for nitrate varied from 0.0 to 11.45 µg at/L with no measurable nitrite.

In all the studies, the nitrogen levels in the bays and estuaries surrounding the eastern Gulf of Mexico were relatively low. The lowest concentrations were found in Perdido Bay while the highest (about four times the lowest) were found in Boca Ciega Bay. It was noted earlier that the rise of phosphate concentrations in the waters was from river runoff and effluents from phosphoric acid manufacture. Nitrogen enhancement in Perdido Bay was found by a USDI study (1969) to be from a pulp mill effluent. Figure 4 shows Hillsboro Bay with the ammonia coming from a sewage treatment plant and Seddon Island activities.

Trace Metals

Even more sparse than the nutrient measurements in the coastal waters of the eastern Gulf of Mexico are the determinations of trace metals. Using neutron activation, Slowey and Hood (1971) analyzed 84 samples from 28 stations for zinc, copper, and manganese. Only about six of these stations represented coastal regions. They found copper values from 0.44 to 2.1 µg/L, manganese from 0.2 to 19.0 µg/L and zinc from 2.6 to 10 µg/L at their shallow-water stations. Both iron and copper were determined by Dragovich *et al*. in their "red tide" studies. They found up to 15 µg Cu/L in the Gulf waters, and from 6.0 to 16.3 µg/L of iron.

Samples for trace metals have been collected in the eastern Gulf of Mexico during the EGMEX program, and there has been a continuing IDOE (International Decade of Ocean Exploration) program of trace-metal sampling in the Mississippi River delta area, but no published results are available. The most intensive study (Corcoran, 1972) of trace elements in coastal Gulf of Mexico waters is the one for the offshore area of Florida's Escambia and Santa Rosa counties (ESCAROSA). In this investigation six trace metals (cadmium, lead, copper, chromium, zinc, and manganese) were measured. Some of the results of this study are shown in Figures 5-11. Cadmium values vary from 0.02 to 0.5 µg/L with two pools of offshore water of higher concentration and a tongue of water coming in from the west. The copper concentrations show somewhat the same picture as that of cadmium,varying from 0.1 to 3.0 µg/L. While chromium is similar, there are two tongues of water coming from the west with the two offshore pools of increased concentration water (greater than 2 ppb). Zinc measurements showed concentrations of 3 to 20 µg/L and a definite tongue of water entering from the west.

Except for the copper concentrations, the average concentrations of the other five trace elements were approximately ten times the concentrations typically observed in open Gulf waters. There also seems to be a general west-to-east water movement on the surface, with waters moving in from Mobile Bay and, possibly, from the Mississippi delta (as indicated by chromium).

The mercury content of the ESCAROSA waters was also measured. The values varied between 0.095 and 0.26 µg/L. For comparison, the waters in the coastal area west of the Everglades were measured (east-west transect on 25°50'N). Here mercury concentrations varied from 3.18 µg/L to 8.75 µg/L with 5.93 µg/L average. There is no explanation as to why this area should be so much higher in mercury.

Summary

No attempt has been made in this brief review to include all the chemical work that has been done in the Gulf of Mexico. The papers serve to show the state of the art.

To summarize: phosphorus in Gulf waters has received the most attention and is the best documented. The question is, is the concentration increasing? Comparisons of early and later studies would seem to indicate this, especially in the Tampa Bay area. Flushing studies show that a 90 percent reduction in concentrations in Tampa Bay was accomplished in approximately 180 days. How much phosphate is lost to the sediments is not well known. The known phosphate data, especially recent studies, should serve as baselines for future studies.

Less studied are the nitrogenous nutrients. Sewage effluents and pulp mills are important sources for these compounds. We need to know the exchange rates with the sediments, but, most important, we need to know the chemical species: ammonia, nitrite, nitrate, and other intermediates, such as amino acids, amines, and the oxides of nitrogen. Berberian's data on nitrites and nitrates will give us a better understanding, but more baseline data are still needed.

Because of their important biochemical and geochemical roles, the trace metals are perhaps the most important, although least is known about them! Some of the questions to be answered are: What is the distribution of these metals? What is the source of these trace metals? One source is river runoff with industrial wastes, certainly, but what about the dump sites and the oil rigs? Fourteen dump sites have been authorized in the Gulf of Mexico--twelve of these are for spoils and two are for industrial chemicals. One of the industrial chemicals sites lies just 60 miles south of the mouth of the Mississippi. Indications are that the north coast of the eastern Gulf and the Loop Current could be receiving these materials.

How much exchange is there between trace metals and the sediments? Experience in the New York Bight area shows this to be highly variable. But most important of all, what are the chemical species? Methyl mercury, for example, is much more toxic than elemental or divalent. We know also that both elemental and divalent mercury can be converted to alkyl mercury, as can arsenic. Many other trace metals such as copper, iron, and manganese have organic forms in the sea. Chemical speciation is a must! All of these problems and many more will be discussed at the workshops, I am sure, along with standardized methods to do them, I hope!

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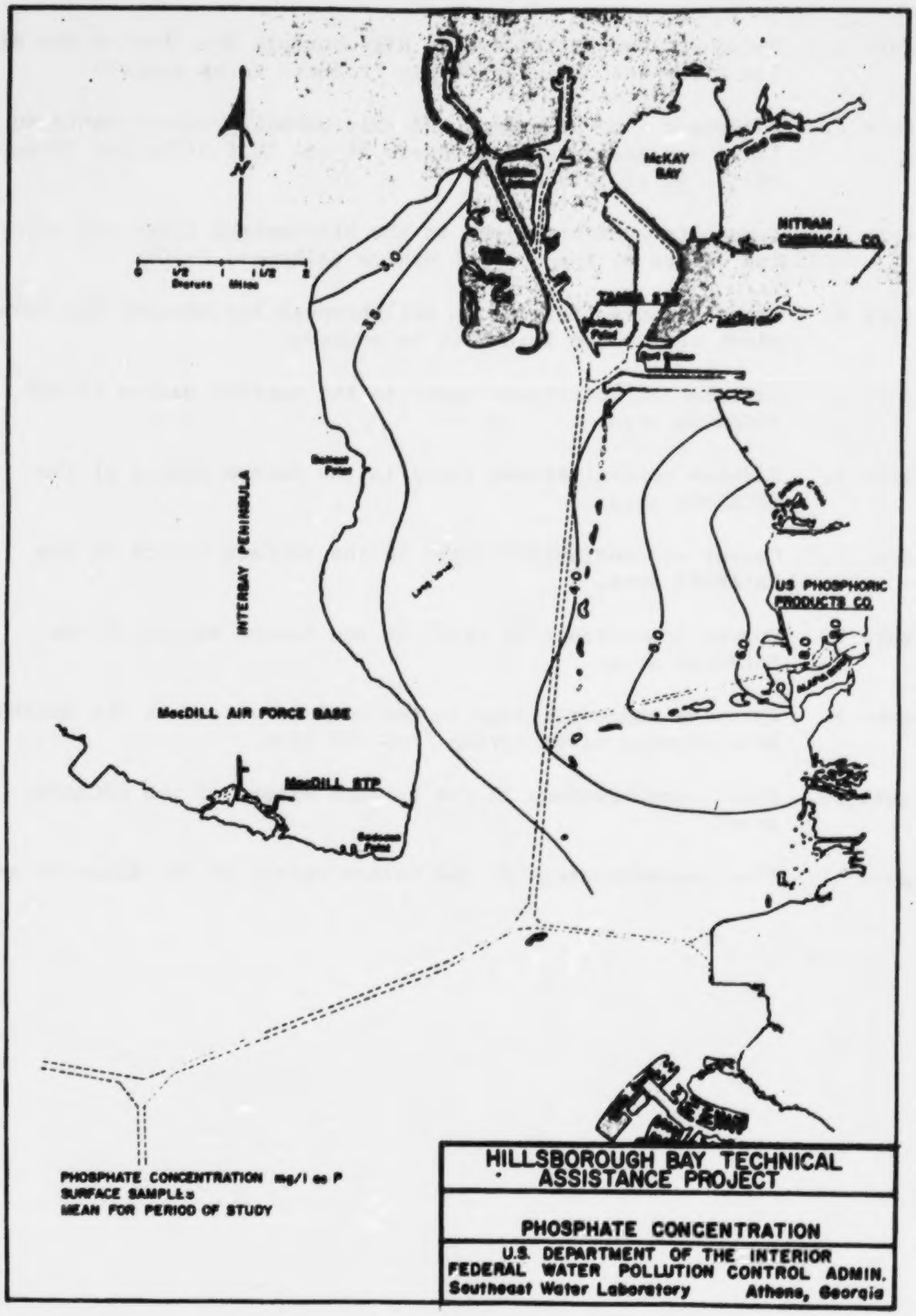
Figure Legends

Figure 1.	Phosphate concentrations in Hillsborough Bay showing the Alafia River and U.S. Phosphoric Products to be sources.
Figure 2.	Phosphate concentrations and chlorophyll *a* measurements in Tampa Bay and adjoining waters of the Gulf of Mexico (Dragovich, *et al*., 1968).
Figure 3.	Phosphate concentrations in the Mississippi River and adjoining waters of the Gulf of Mexico (Alberts, 1970).
Figure 4.	Ammonia concentrations in Hillsborough Bay showing the sewage plant and Seddon Island to be sources.
Figure 5.	Cadmium concentrations (ppb) in the surface waters of the ESCAROSA area.
Figure 6.	Cadmium concentrations (ppb) in the bottom waters of the ESCAROSA area.
Figure 7.	Copper concentrations (ppb) in the surface waters of the ESCAROSA area.
Figure 8.	Copper concentrations (ppb) in the bottom waters of the ESCAROSA area.
Figure 9.	Chromium concentrations in the surface waters of the ESCAROSA area showing water moving from the west.
Figure 10.	Zinc concentrations in the surface waters of the ESCAROSA area.
Figure 11.	Zinc concentrations in the bottom waters of the ESCAROSA area.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TAMPA STP
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6.0
INTERBAY PENINSULA
US PHOSPHORIC PRODUCTS CO.
MacDILL AIR FORCE BASE
MacDILL STP
PHOSPHATE CONCENTRATION mg/l as P
SURFACE SAMPLES
MEAN FOR PERIOD OF STUDY
HILLSBOROUGH BAY TECHNICAL ASSISTANCE PROJECT
PHOSPHATE CONCENTRATION
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
Southeast Water Laboratory
Athens, Georgia

FIGURE 1

Mean concentrations of chlorophyll a, iron, and inorganic phosphate-phosphorus in Florida west coast tributaries and adjacent bays and neritic waters of the Gulf of Mexico, January 1964 and January 1965

[S = surface; B = bottom]

Location	Chlorophyll "a"		Iron		PO$_4$-P	
	S	B	S	B	S	B
Tampa Bay area	mg./m.^{3}	mg./m.^{3}	µg./l.	µg./l.	µg.at./l.	µg.at./l.
Rivers:						
Hillsborough	12.41	12.03	202.4	235.0	9.6	19.1
Alafia	8.13	12.04	216.6	381.0	33.6	29.1
Little Manatee	3.92	5.05	187.5	219.0	22.2	24.8
Manatee	5.44	7.68	217.0	251.6	15.1	16.6
Bays:						
Old Tampa Bay	5.56	9.40	115.0	. . . .	23.2	25.8
Hillsborough Bay	30.22	19.47	147.8	. . . .	24.4	24.0
Upper Tampa Bay	6.78	7.37	74.1	. . . .	22.2	24.0
Lower Tampa Bay	3.14	3.37	40.6	. . . .	14.5	16.4
Gulf:						
9.3 km. off Tampa Bay	1.17	1.03	16.3	19.4	2.6	3.2
18.5 km. off Tampa Bay	3.78	0.95	. . . .	. . . .	1.4	0.9
27.8 km. off Tampa Bay	6.50	.54	. . . .	. . . .	0.6	1.8
37.1 km. off Tampa Bay	.36	.58	6.0	5.3	.4	.6
Charlotte Harbor area						
Rivers:						
Myakka:						
Station 6	7.18	6.76	622.9	683.0	9.6	7.1
Station 5	5.25	5.79	299.2	434.3	6.3	7.2
Peace:						
Station 8	82.28	49.93	460.6	490.4	32.6	30.7
Station 7	8.74	9.89	329.7	305.9	18.6	18.4
Caloosahatchee:						
Station 10	10.65	13.53	265.8	535.5	2.4	4.4
Station 9	12.13	17.94	332.9	414.3	6.2	6.4
Bays:						
Upper Charlotte Harbor	2.73	2.80	111.9	111.6	11.5	9.3
Lower Charlotte Harbor	2.37	2.28	93.3	76.4	10.4	5.8
Gulf:						
9.3 km. off Boca Grande	1.86	1.28	26.0	20.3	1.6	1.1
18.5 km. off Boca Grande	.95	.53	. . . .	. . . .	.7	1.0
27.5 km. off Boca Grande	.54	.42	. . . .	. . . .	1.0	.7
37.1 km. off Boca Grande	.28	.29	16.5	4.6	.7	.6

From Dragovich et al., 1968.

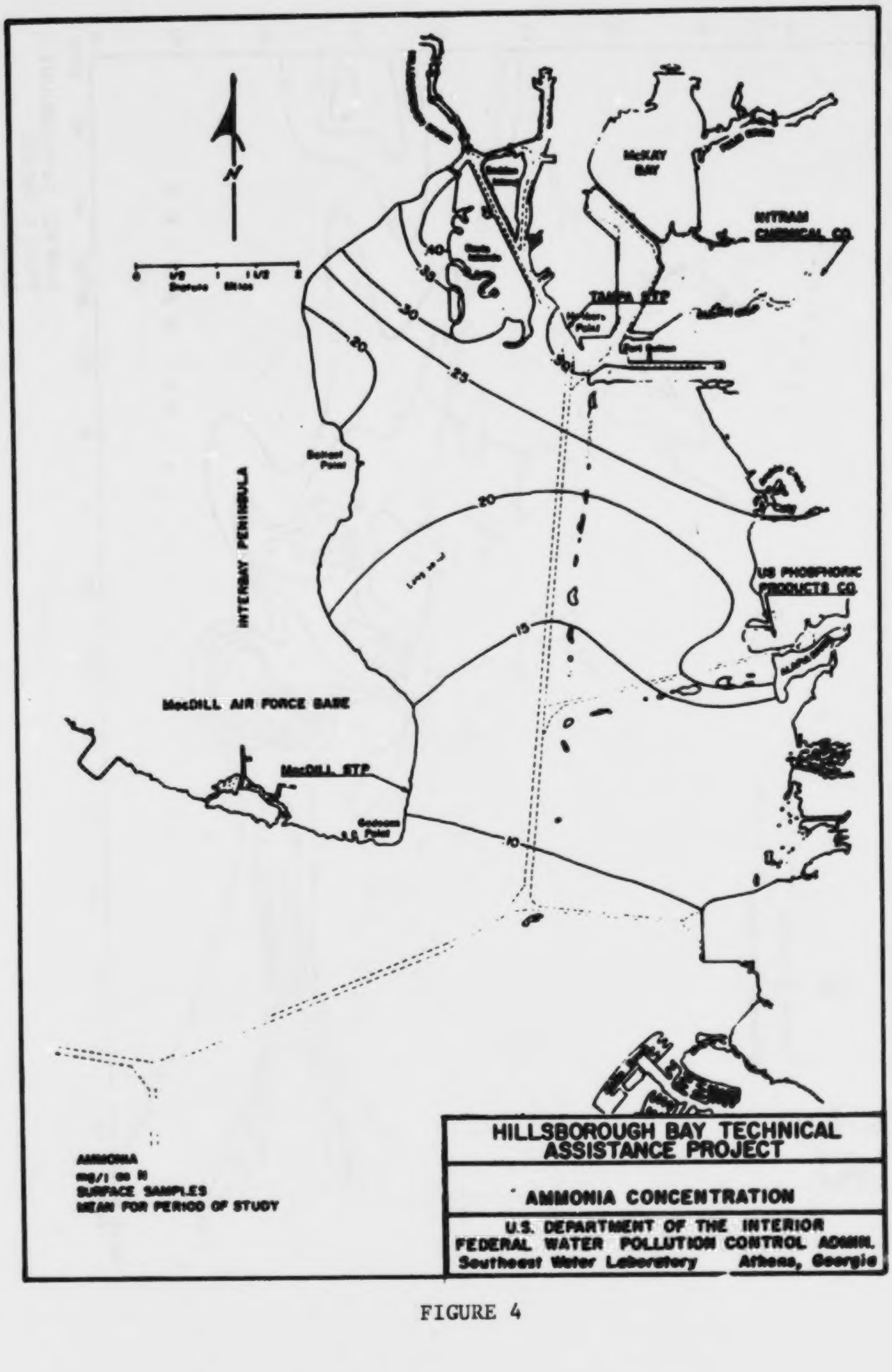
FIGURE 2

Mississippi River Surface Water Salinity and Phosphorus Data.

Sta. No.	Location	Water Depth	µg. at P/L	S 0/00
T-11-12	112.9 miles north of Head of Passes. Miss. R.		2.90	0.22
T-11-13	118 miles north of Head of Passes. Miss. R.		4.13	0.19
T-11-14	85.4 miles north of Head of Passes. Miss. R.		2.97	0.20
T-11-15	54.0 miles north of Head of Passes. Miss. R.		2.78	0.21
T-11-16	27.7 miles north of Head of Passes. Miss. R.		2.55	0.23
T-11-17	Head of Passes		2.84	0.25
T-11-18	900 meters south of Head of Passes. Miss. R.		1.36	15.30
T-11-21	28° 52' N 89° 02' W	300 m	0.48	36.20

From Alberts, 1970.

FIGURE 3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Distance Miles
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MacDILL AIR FORCE BASE
MacDILL STP
Ballast Point
Gadsden Point
McKAY BAY
NITRAM CHEMICAL CO.
TAMPA STP
Hookers Point
Port Sutton
US PHOSPHORIC PRODUCTS CO.
40
30
30
25
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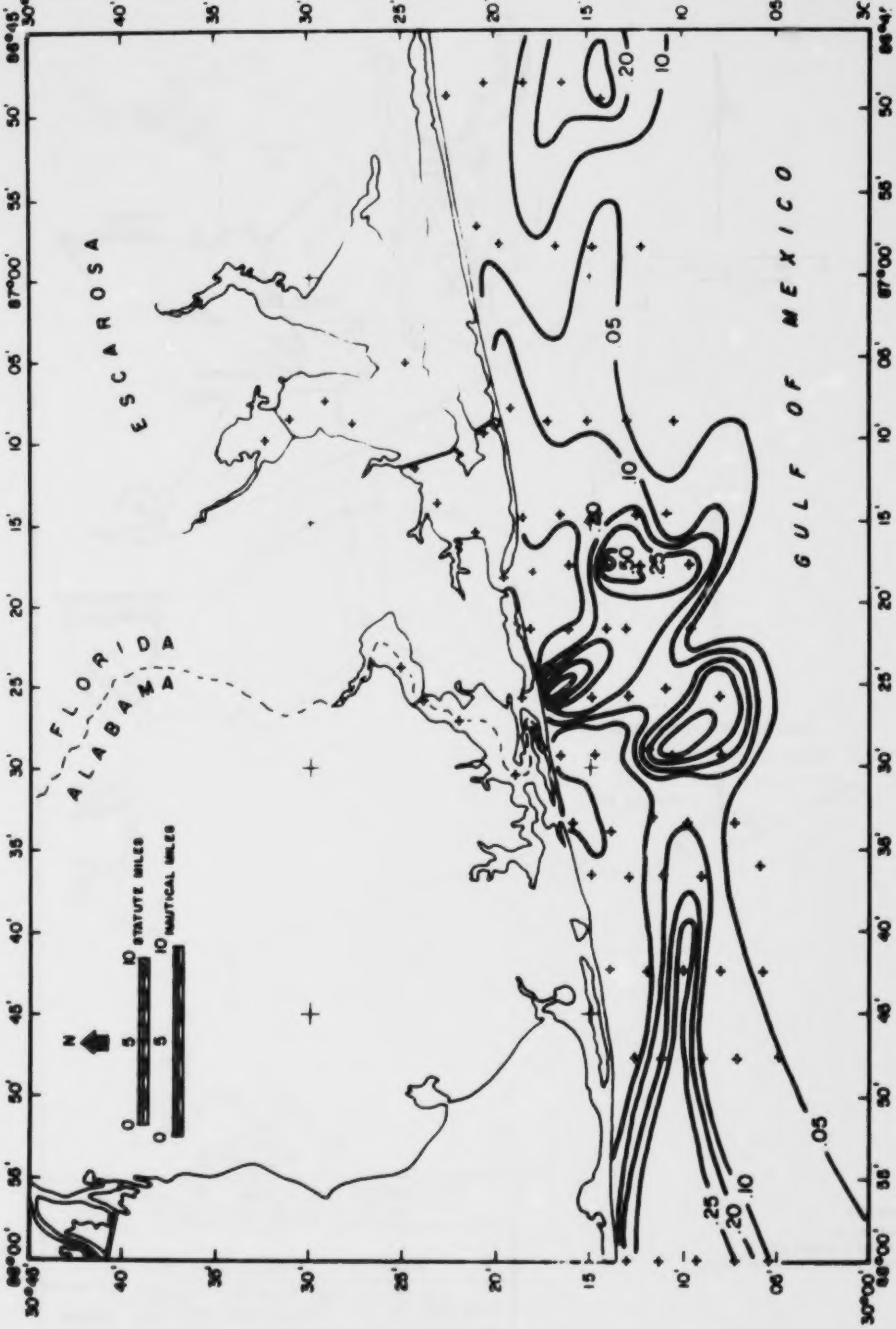
15
10
AMMONIA
mg/l as N
SURFACE SAMPLES
MEAN FOR PERIOD OF STUDY
HILLSBOROUGH BAY TECHNICAL ASSISTANCE PROJECT
AMMONIA CONCENTRATION
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
Southeast Water Laboratory Athens, Georgia

FIGURE 4



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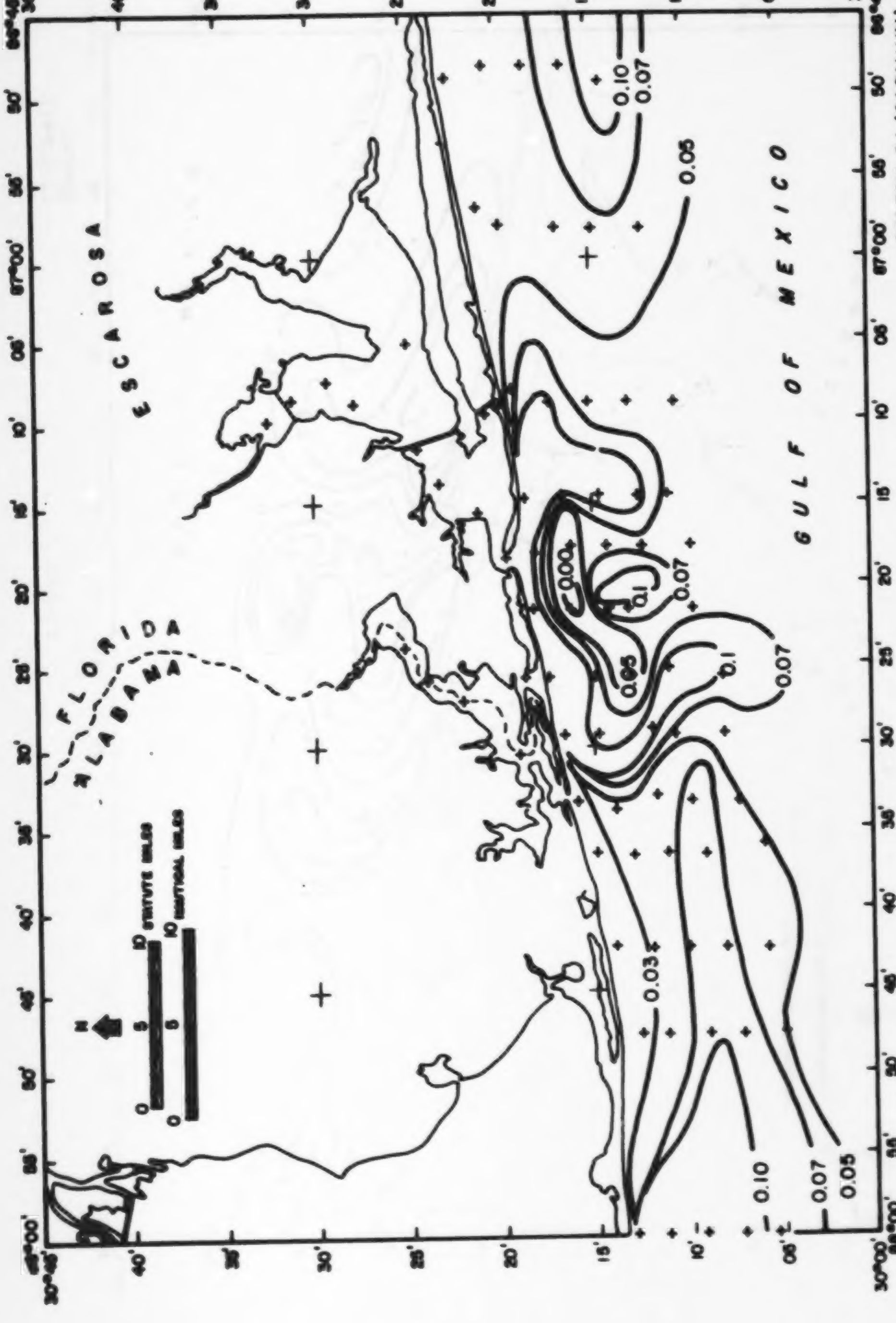
SURFACE Cd (CADMIUM)
TRACE ELEMENTS
ESCAROSA I

FIGURE 5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40'
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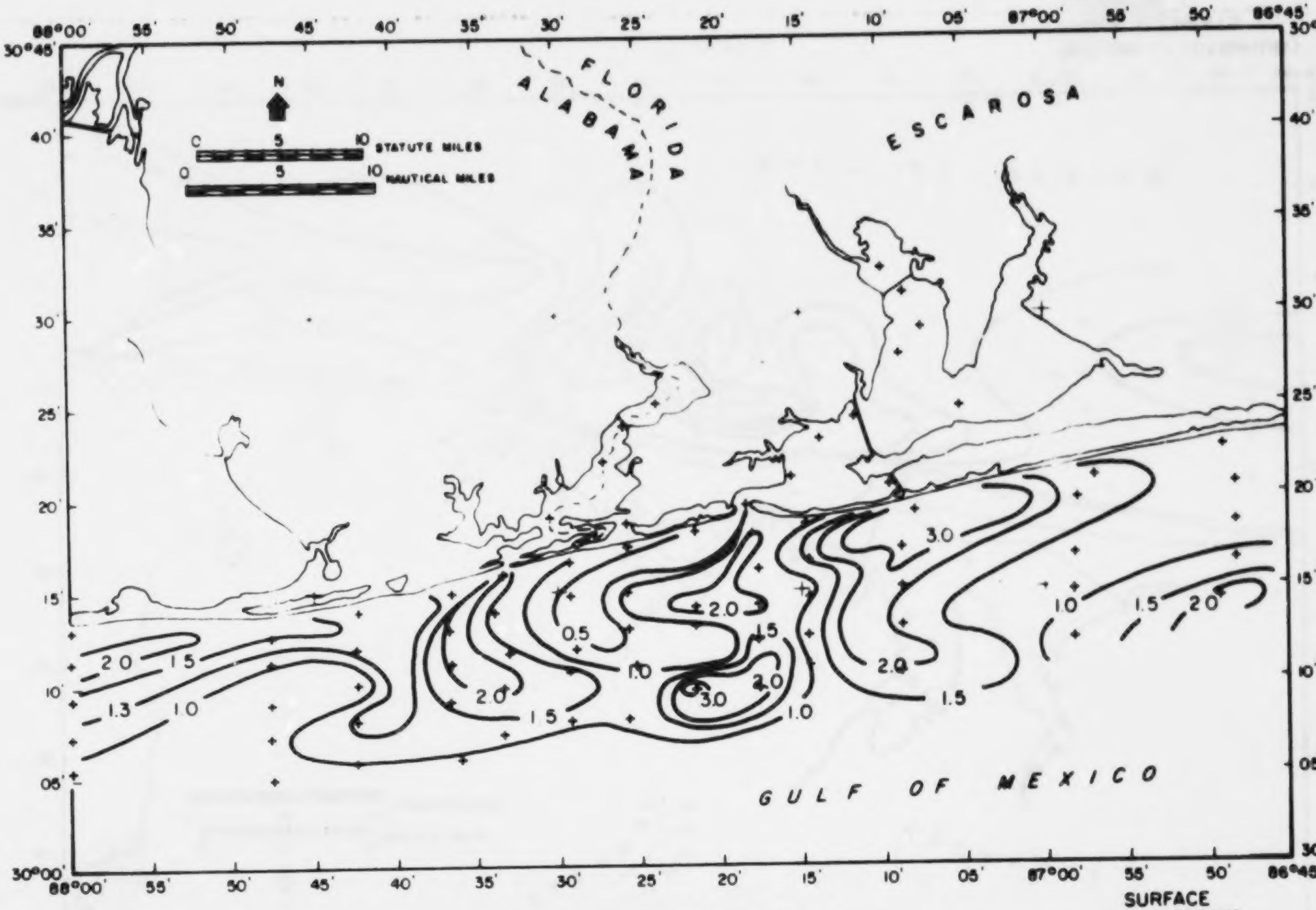
55'
88°00'

BOTTOM Cd (CADMIUM)
TRACE ELEMENTS
ESCAROSA I

FIGURE 6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ESCAROSA
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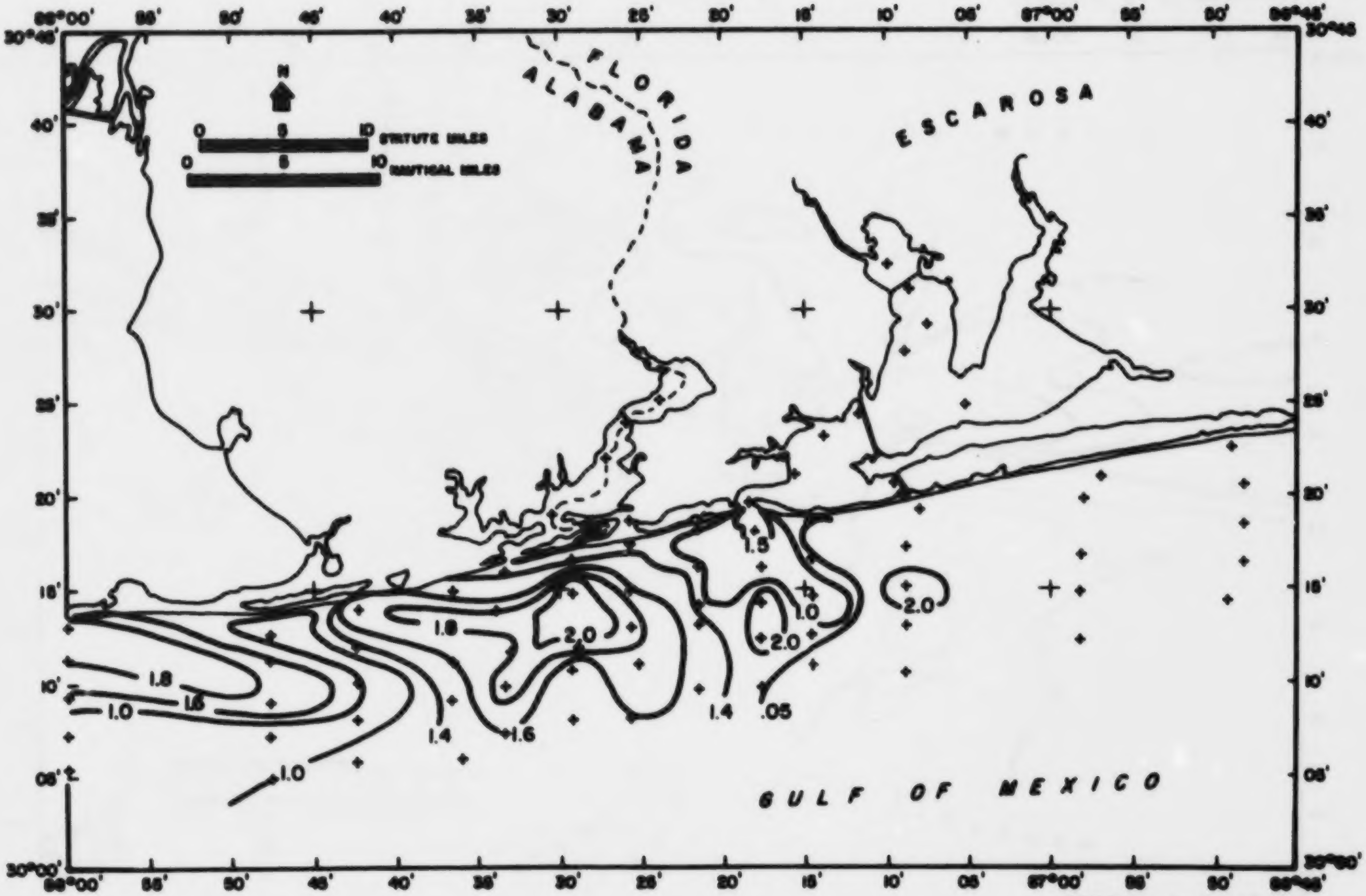
SURFACE
Cu (COPPER)

FIGURE 7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0 5 10 NAUTICAL MILES
FLORIDA
ALABAMA
ESCAROSA
GULF OF MEXICO
1.8
1.6
1.0
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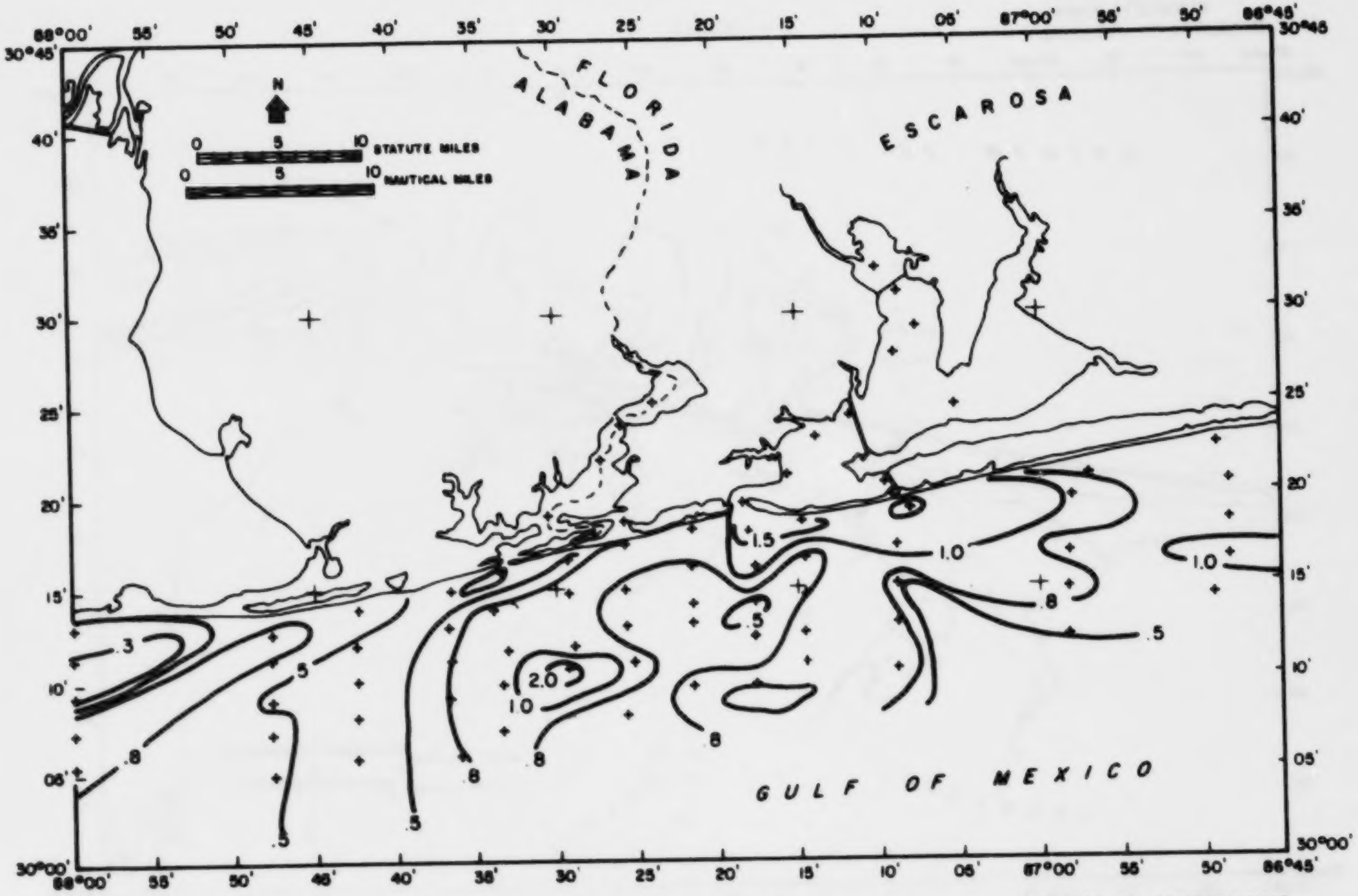
1.0
1.8
2.0
1.6
1.4
.05
1.5
1.0
2.0
2.0

FIGURE 8

BOTTOM Cu (COPPER)
TRACE ELEMENTS
ESCAROSA I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86°45'
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1.0
1.5
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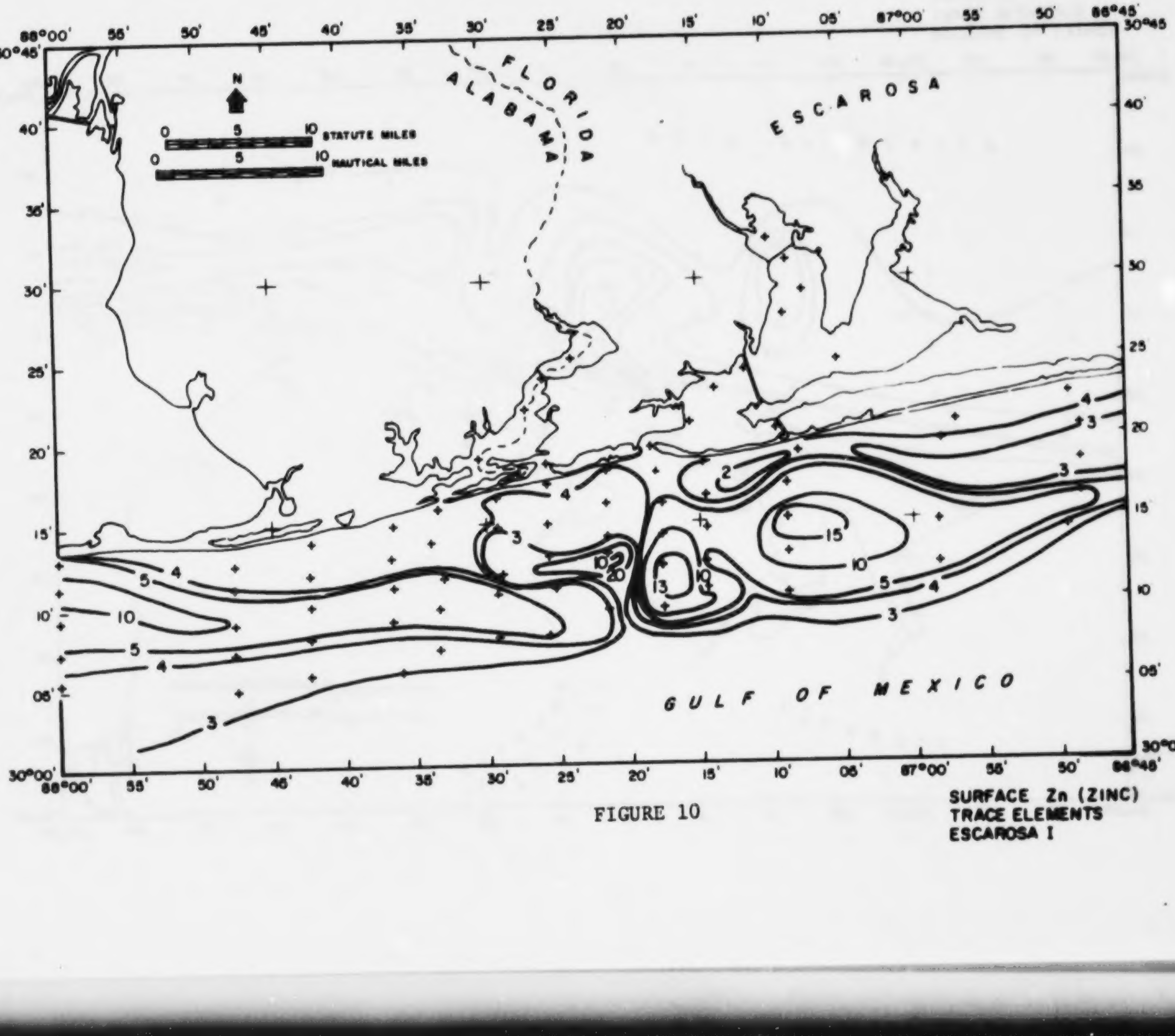
FIGURE 9

SURFACE Cr (CHROMIUM)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25'
20'
15'
10'
05'
30°00'
N
0 5 10 STATUTE MILES
0 5 10 NAUTICAL MILES
FLORIDA
ALABAMA
ESCAROSA
GULF OF MEXICO
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3
4
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13
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20

FIGURE 10

SURFACE Zn (ZINC)
TRACE ELEMENTS
ESCAROSA I

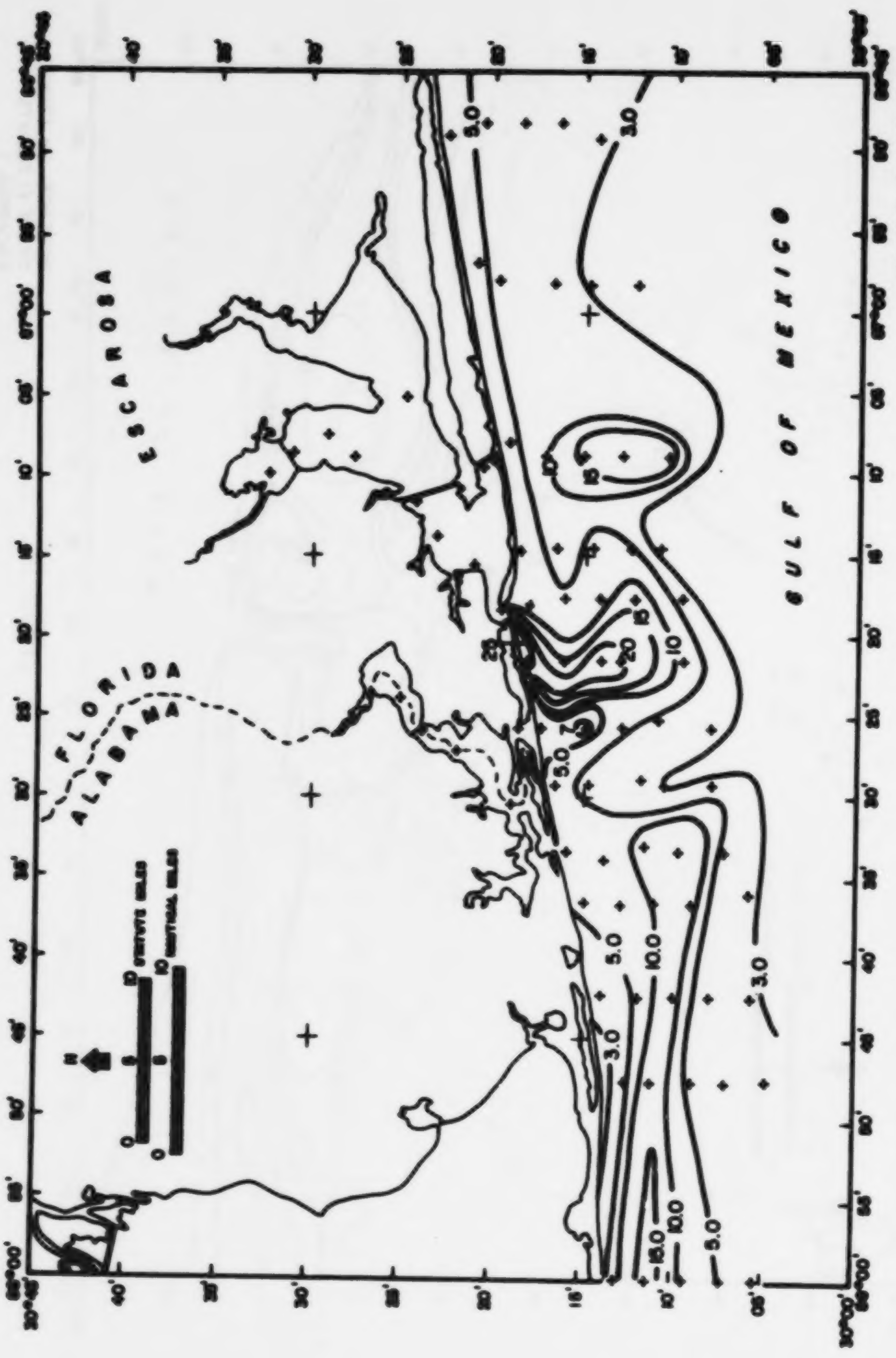
BOTTOM Zn (ZINC)
TRACE ELEMENTS
ESCAROSA I
ESCAROSA
FLORIDA
ALABAMA
GULF OF MEXICO
STATUTE MILES
NAUTICAL MILES
N
0
10
3.0
5.0
10
10.0
15
15.0
20
25

FIGURE 11

Significance of Low Molecular Weight Hydrocarbons in Eastern Gulf Waters

William M. Sackett
Department of Oceanography
Texas A & M University
College Station, Texas

Introduction

The International Decade of Ocean Exploration (IDOE) was announced in 1968 as a long-term, international, cooperative program that would help man understand, preserve and exploit, in a controlled manner, the ocean and its resources. Since 1970, IDOE has provided much of the total funding of oceanographic research in various institutions in this country. One of the charges of IDOE was oceanic environmental quality. However, when program managers attempted to determine what research should be done on the effects of various pollutants on the ocean, they discovered that the concentration levels of these pollutants in the water, organisms and sediments were relatively unknown. This realization lead to a series of baseline studies in the Atlantic and Pacific Oceans, and the Gulf of Mexico and Caribbean Sea.

I coordinated and was responsible for the at-sea collections of the baseline study in the Gulf of Mexico and Caribbean, which took place in 1971. Two long cruises and several shorter ones covered most of these two bodies of water. Samples of water, organisms and sediments were carefully collected for measurement of the main classes of pollutants. The chlorinated hydrocarbons and metals were determined by groups headed by C. S. Giam and B. J. Presley, both of Texas A & M University; the high molecular weight hydrocarbons (petroleum) were determined by a group at the University of Texas at Port Aransas under the direction of P. L. Parker. While collecting samples for these groups, J. M. Brooks, a graduate student working with me, and I were determining the concentration levels of the low molecular hydrocarbons along most of the 2500-mile tracks of the two major cruises. Reported here is a summary of our results, most of which have been published in papers by Brooks, et al., (1973) and Brooks and Sackett (1973).

Procedure

Gas analyses were performed with a modified Beckman Process Gas Chromatograph. For surface profiling, gases are continuously stripped from the sea water by a 12-stage booster pump which has a restricted inflow (1.6 L/min.). The vacuum produced by the restriction of the booster pump inflow "strips" about 50% of the total gases from solution. Analysis of water before and after "stripping" indicates that approximately 50% of the light hydrocarbons are also "stripped." The "stripped" gases are collected and are pushed by hydrostatic pressure through a

1.76 ml sample loop. The gases in the sample loop are injected approximately every 5 minutes into the chromatographic stream for analysis. Water for surface profiling was obtained from the sea chest of the R/V Alaminos. The sea chest intake is about three meters below the sea surface. About 75% of the stream-flow from the sea chest (6 L/min.) bypasses the booster pump to keep lag time in the system short. There is a ten minute lag between the time the water enters the sea chest and the "stripped" gases reach the detector for analysis.

The gas chromatographic system consists of a flame ionization detector with either a 10% Nujol on alumina or Proapak Q column. A partial schematic of the system is shown in Figure 1. With this system it is possible to analyze for light hydrocarbon by three different methods. First, relative hydrocarbon values are obtained in surface profiling by "stripping" gases as described above. Absolute values can be obtained by McAullife's (1971) method of multiple phase equilibrium. This method involves equilibrating 25 ml of purified helium with 25 ml of sample water in a 50 ml syringe. A portion of the equilibrated helium is injected into the chromatographic stream by means of the sample loop. For open ocean concentrations of light hydrocarbons this method is sensitive enough only for methane, but in waters with higher concentrations (e.g., the Upper Gulf Coast and harbors) this technique offers a quick and easy method for determining both methane and higher hydrocarbons. For lower concentrations of light hydrocarbons the technique of Swinnerton and Linnenbom (1967) is used. This involves purging one liter of sea water with purified helium and collecting the light hydrocarbons in two cold traps for subsequent injection into the helium stream when the traps are heated. Standardization of the system is accomplished by injecting 1.26 μl of a gas standard into the chromatographic stream.

The light hydrocarbon data obtained from the "sniffer" during surface profiling are relative values since total extraction of the gases from the sea water is not obtained. The open ocean values are assigned a relative value of one, making the relative hydrocarbon concentrations reported in this paper multiples of open ocean concentrations. Thus, a relative methane level of 10 will be approximately equal to 50×10^{-5} ml/L or ten times the open ocean level for methane of 5×10^{-5} ml/L. Comparison of relative methane values obtained by the "sniffer" with absolute concentrations determined by McAullife's method shows that the proportion of methane that is extracted with the total gases is fairly linear with increasing concentrations above open ocean levels.

Results and Discussion

Figure 2 is a base map showing the sampling locations of some of the hydrocarbon data which follow. Fortuitously our cruise track took us through the area of the recent outer continental shelf lease sale offshore Mississippi, Alabama, and Florida. Figure 3 gives some of the relative methane concentrations, as determined by our "sniffer" system, for some of this cruise track. High values are observed over Claypile Bank, location of a known natural gas seep, near the port of Galveston, near a tanker on a bank in the Caribbean, and near a bank of the Yucatan shelf. No obvious source was seen for the latter anomaly but this location is near the heavily traveled shipping lanes. Anomalously low, typical deep water values were observed in areas of known upwelling or outcropping of deep water along the western Yucatan Strait. This observation is just what would be expected. These low values also point out that areas of upwelling are "sinks" for hydrocarbons in the atmosphere. Open ocean surface water concentrations of about $5x10^{-5}$ ml CH_4/liter are the equilibrium values determined by the partial pressure of methane in the atmosphere. Lower values than the above suggest a flux into the sea, higher values a flux out of the sea surface.

Figure 4 gives relative methane values for 71-A-5, a previous cruise in the western Gulf of Mexico. The letters along the abscissa indicate direction and are located at the approximate points where course changes were made. Normal open ocean surface values are seen for the middle of the Gulf with high values in and around three ports: Galveston, Puerto Mexico and the Mississippi River Passes.

Figure 5 indicates that relative ethane, propane and butane concentrations are much more pronounced than relative methane concentrations in the anomalous areas previously described. Several orders of magnitude higher values are seen in the two areas where tanker sources are the plausible explanations.

Figures 6 and 7 show relative methane values across the Florida and Louisiana-Texas shelves, respectively. It is interesting to note that the Florida shelf had near normal open ocean values except near Pensacola Bay, whereas the Texas-Louisiana values were generally much higher with several major anomalies. These high values, in one case more fully investigated, extended all the way to the bottom. The anomalies seem to be associated with the drilling and producing platforms, which could be seen from five to ten miles away from the ship.

Typical "sniffer" chromatograms shown in Figure 8 point out the most important man-derived sources of low molecular weight hydrocarbons in the Gulf: ports with their associated shipping and petrochemical activities; offshore petroleum drilling and production platforms and ships, especially tankers, that discharge oily ballast water and/or clean their fuel tanks at sea.

Although it appeared that the high hydrocarbon concentrations along the Texas-Louisiana shelf were associated with drilling and producing platforms, it is not absolutely certain that they were all due to man's activities. They may have been due, in part, to natural gas seeps which are known to exist in the area. In the past couple of years a considerable number (~100) of these seeps have been discovered by the geophysical group at Texas A & M during routine acoustical subbottom profiling in the Gulf. Apparently gas bubbles with diameters of one to two millimeters, according to Guinasso and Schink (1973), reflect acoustical pulses and these show up as pictured on the fathogram in Figure 9 using 12 kiloherz acoustical pulses or similarly, and better yet, a 3.5 kiloherz fathogram. In their theoretical study, Guinasso and Schink (1973) suggest that about 50% of the mass of these bubbles dissolve on rising through a water column of 40 meters. Solution of these bubbles results in increased concentrations, as pictured in Figure 10, for a series of water samples collected over a seep by W. Sweet and analyzed by J. Brooks. Interestingly, several of these near bottom samples contained relatively high amounts of unsaturated hydrocarbons, not found in petroleum, as well as saturated C_2, C_3, and C_4 hydrocarbons found in petroleum but generally not thought to be associated with biological activity. It appears that a chemical or biochemical dehydrogenation reaction is taking place. This reaction deserves further study for it suggests that some petroleum-derived hydrocarbons may be degrading at a fast rate.

In conclusion, it appears that both natural and man-derived sources of petroleum hydrocarbons give rise to anomalously high concentrations of the low molecular weight components over areas and volumes much larger than the visible manifestation of bubbles from natural seeps or the effluent from offshore platforms and ships. As much of the mass of the bubbles from natural gas seeps goes into solution on rising through the water column, near-bottom concentrations should be most indicative of the presence of these seeps. On the other hand, near-surface concentrations of low molecular weight hydrocarbons should be indicative of man's contributions. The impending environmental baseline program on the outer continental shelf of Florida presents an ideal opportunity to determine the hydrocarbon history of an offshore area, from a relatively virgin to a highly developed state. It is my recommendation that a detailed near-bottom and near-surface low molecular weight hydrocarbon survey be made concomitantly with an acoustical profiling program for seep detection as soon as possible. Following this initial crash study, a more leisurely seasonal monitoring program for just the near-bottom and near-surface hydrocarbon concentrations during the entire outer continental shelf drilling and production operation is recommended. These periodic surveys should allow an early warning of possible damage to the Eastern Gulf Coast ecosystem.

Acknowledgement

All of the hydrocarbon measurements reported in this presentation were made by J. M. Brooks as part of his doctoral dissertation research. The developmental help of A. D. Fredericks and consultations with J. W . Swinnerton are gratefully acknowledged. This work was supported by NSF Grant Nos. GX-30196 and GX-37344.

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________________ and W. M. Sackett.1973. Sources, sinks, and concentrations of light hydrocarbons in the Gulf of Mexico. J. Geophys. Res. 78:5248-5258.

Guinasso, N. L. and D. R. Schink. 1973. A simple physicochemical acoustic model of methane bubbles rising in the sea. Texas A & M University Report, December 30, 1973.

McAullife, C. 1971. Gas chromatographic determination of solutes by multiple phase equilibration. Chem. Tech. 7:46-51

Swinnerton, J. W. and V. J. Linnenbom. 1967. Determination of the C_1 to C_4 hydrocarbons in sea water by gas chromatography. J. Gas Chromatog. 5:570-573.

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Figure 8	Three typical gas chromatograms. Methane is attenuated relative to other peaks, X10 in _a_ and _b_ and X100 in _c_ .
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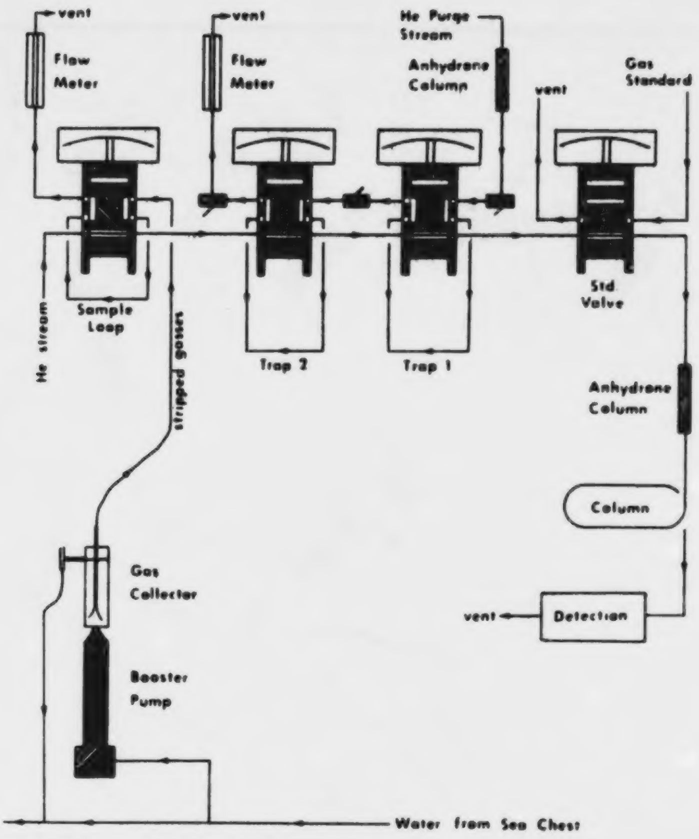
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Flow Meter
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Flow Meter
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Anhydrone Column
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Gas Standard
He stream
Sample Loop
stripped gasses
Trap 2
Trap 1
Std. Valve
Anhydrone Column
Column
Gas Collector
vent
Detection
Booster Pump
Water from Sea Chest

Fig. 1 Schematic of series D analyzer of Beckman process gas chromatograph (after Brooks and Sackett, 1973).

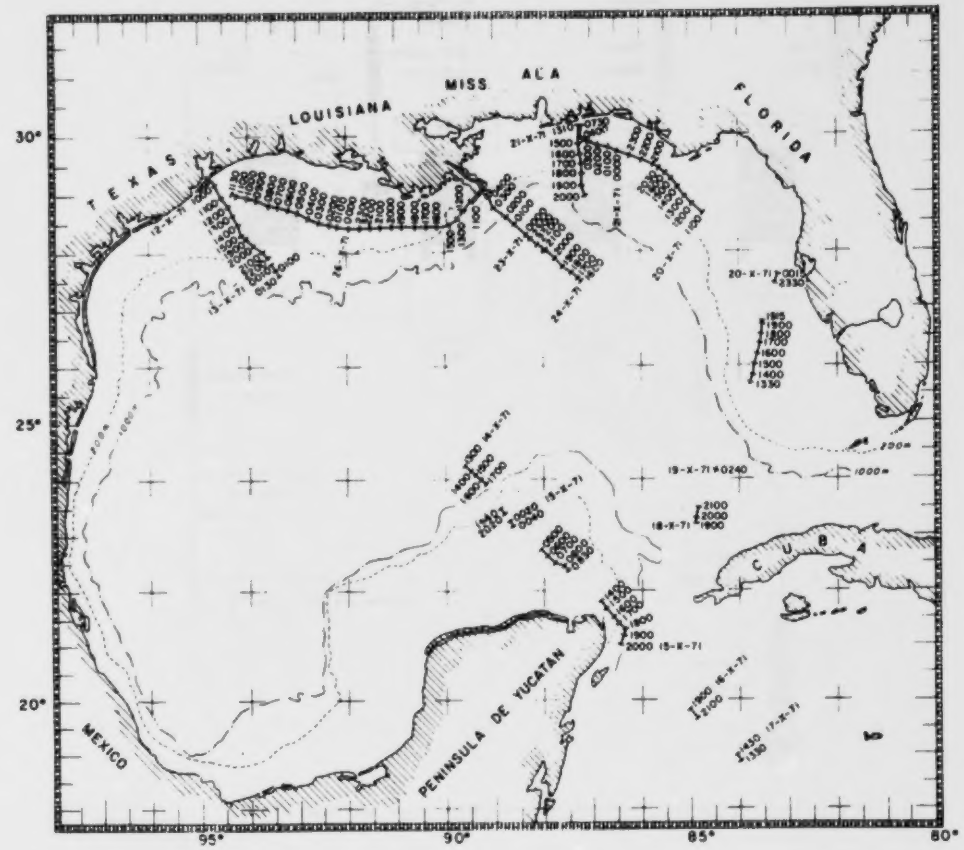
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Fig. 2 Cruise track for 71-A-12. This is the base map for the surface hydrocarbon distributions (after Brooks and Sackett, 1973).

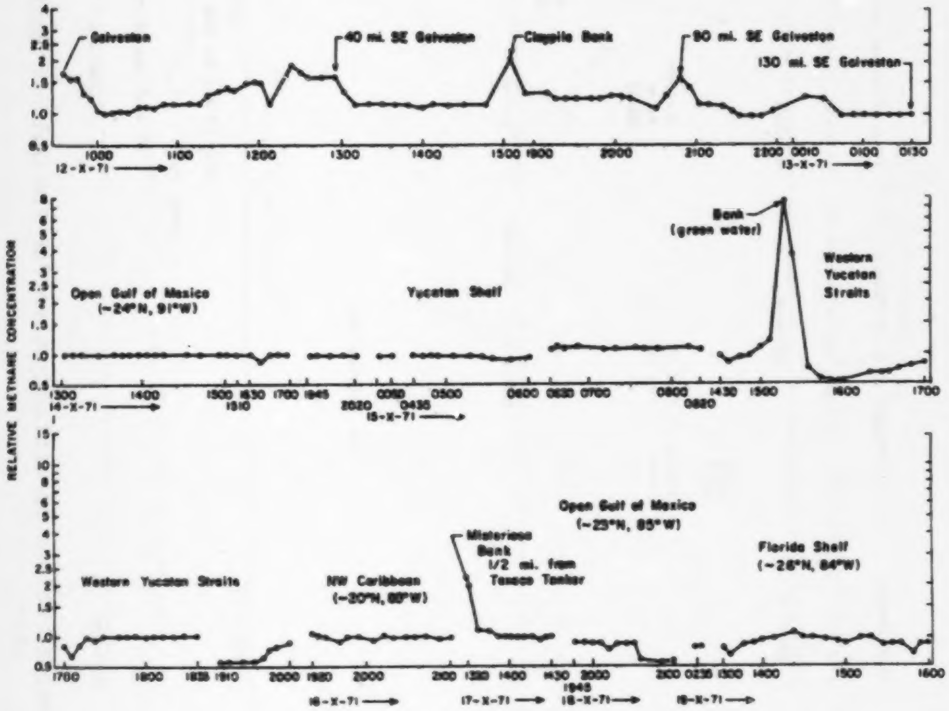


Fig. 3 Relative methane concentrations in the Gulf of Mexico (after Brooks and Sackett, 1973).

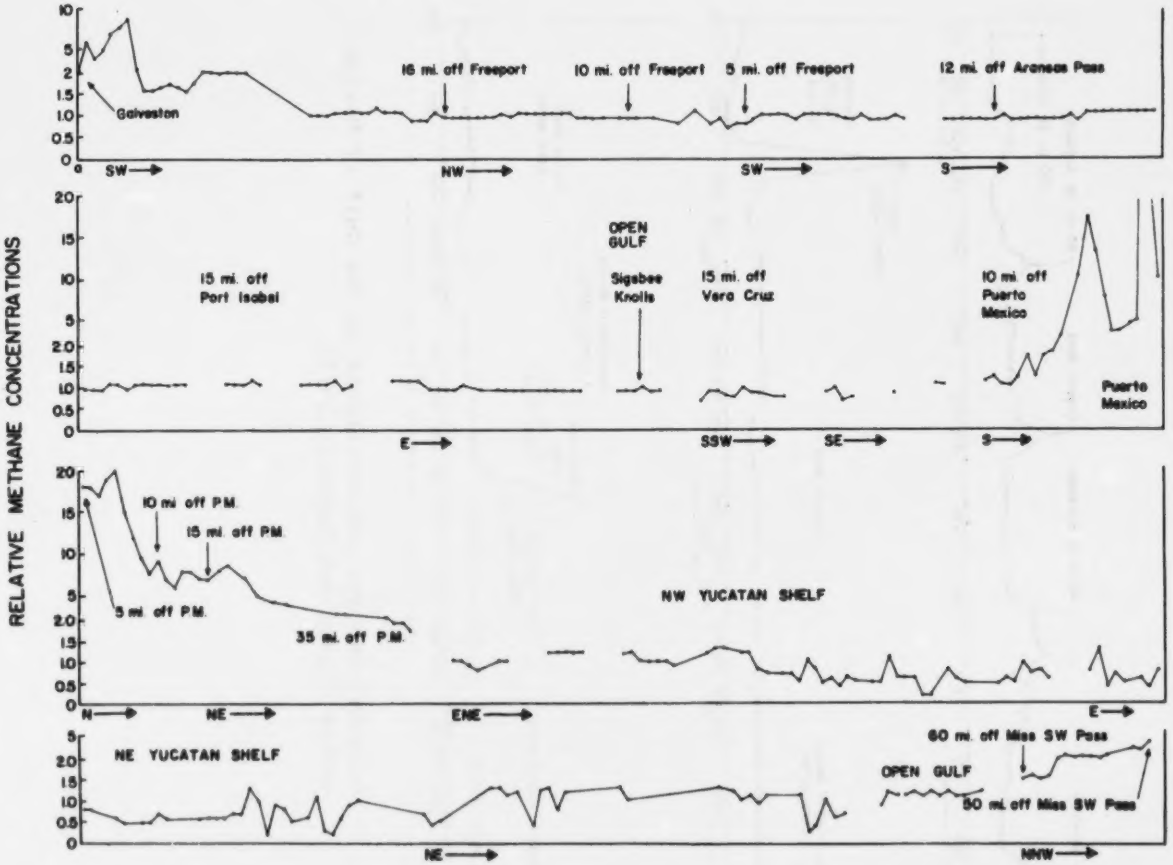


Fig. 4 Relative methane concentrations in surface water for the Gulf of Mexico (after Brooks et al., 1973).

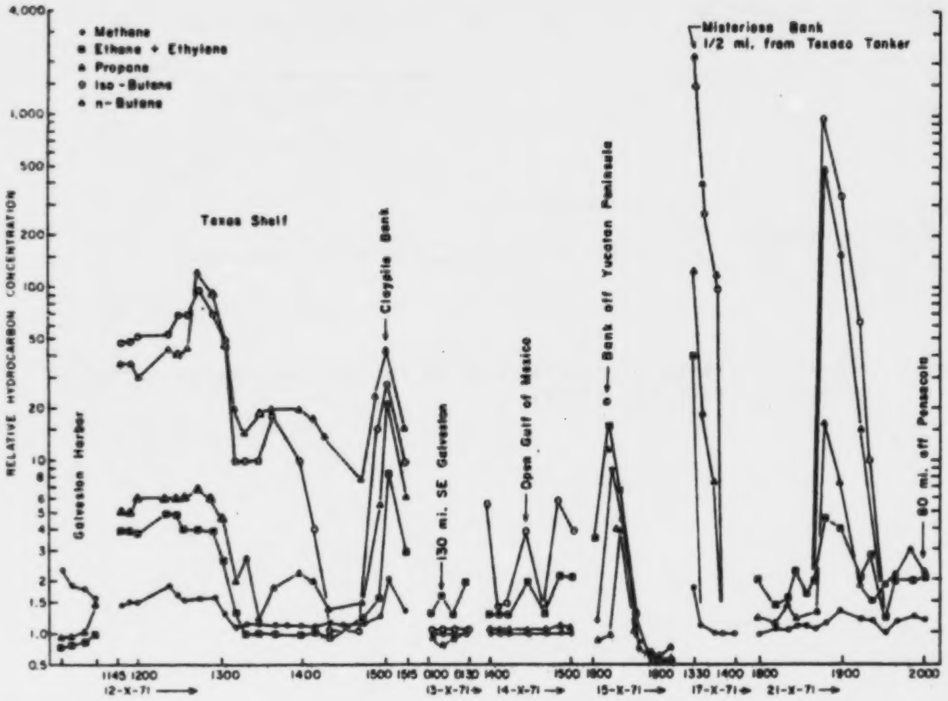


Fig. 5 Relative light hydrocarbon concentrations in the Gulf of Mexico (after Brooks and Sackett, 1973).

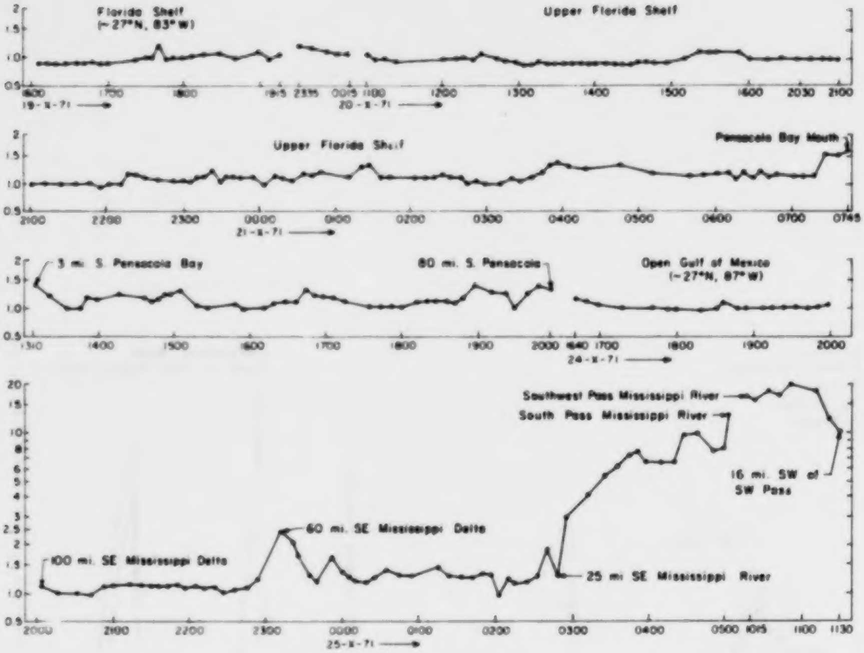


Fig. 6 Relative methane concentrations in the Gulf of Mexico (after Brooks and Sackett, 1973).

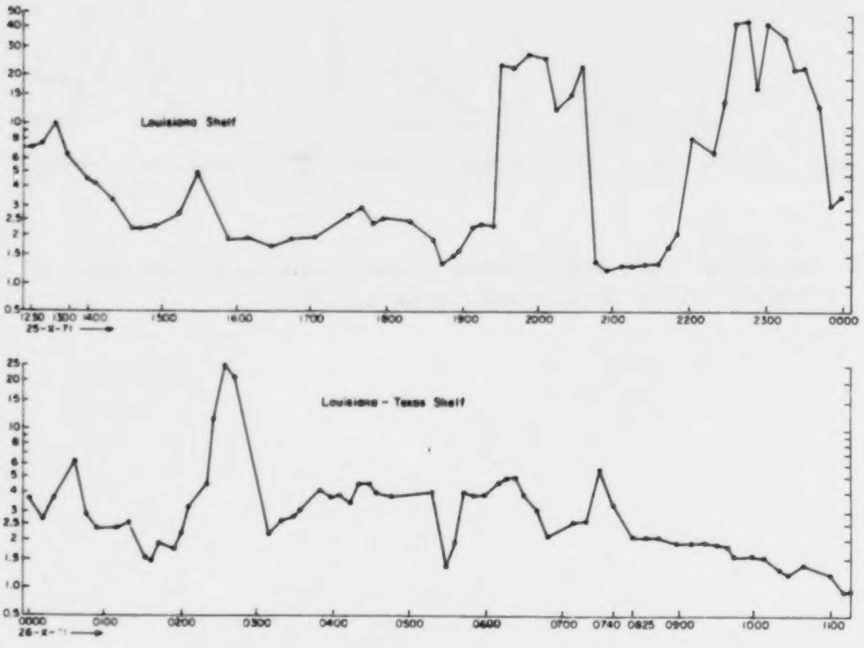


Fig. 7 Relative methane concentrations along the Texas-Louisiana shelf (after Brooks and Sackett, 1973).

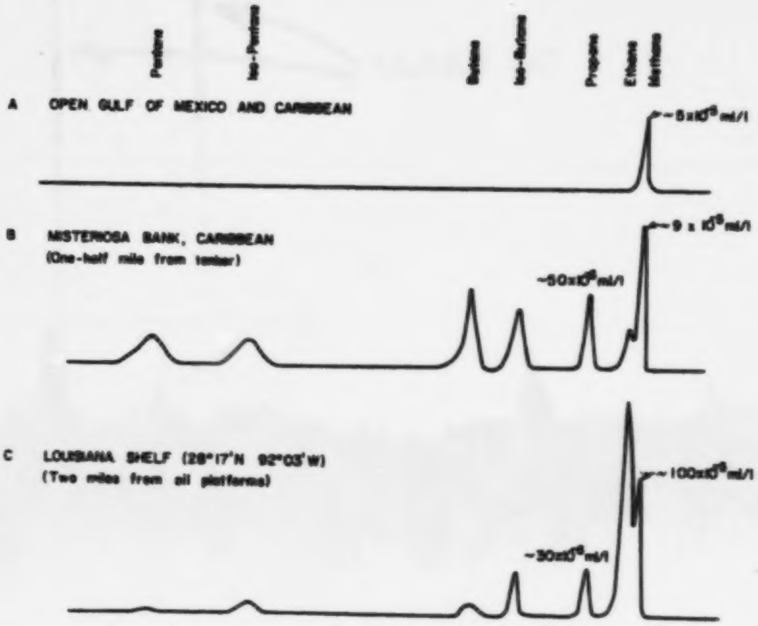


Fig. 8 Three typical gas chromatograms. Methane is attenuated relative to other peaks, X10 in a and b, and X100 in c (after Brooks and Sackett, 1973).

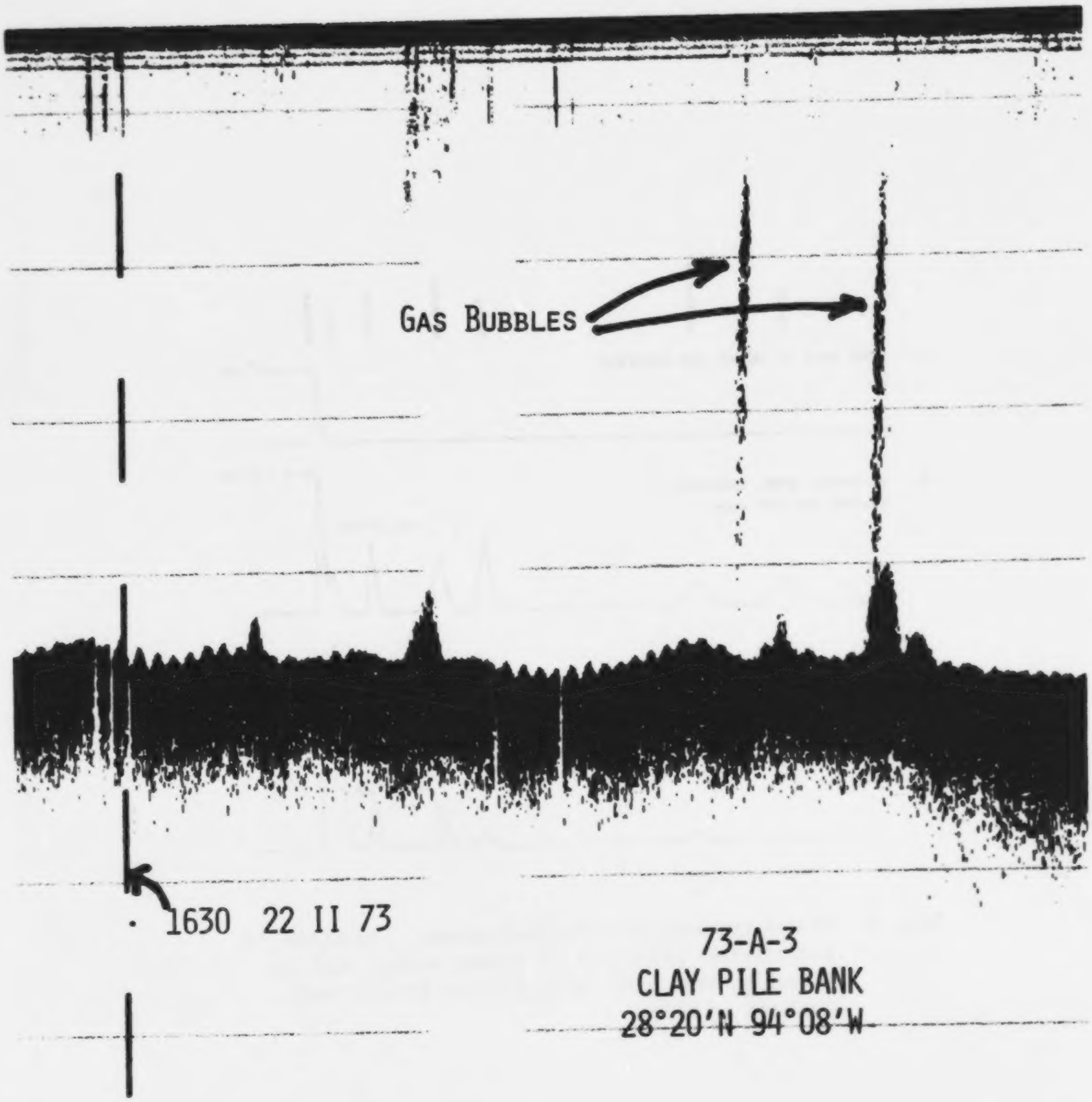
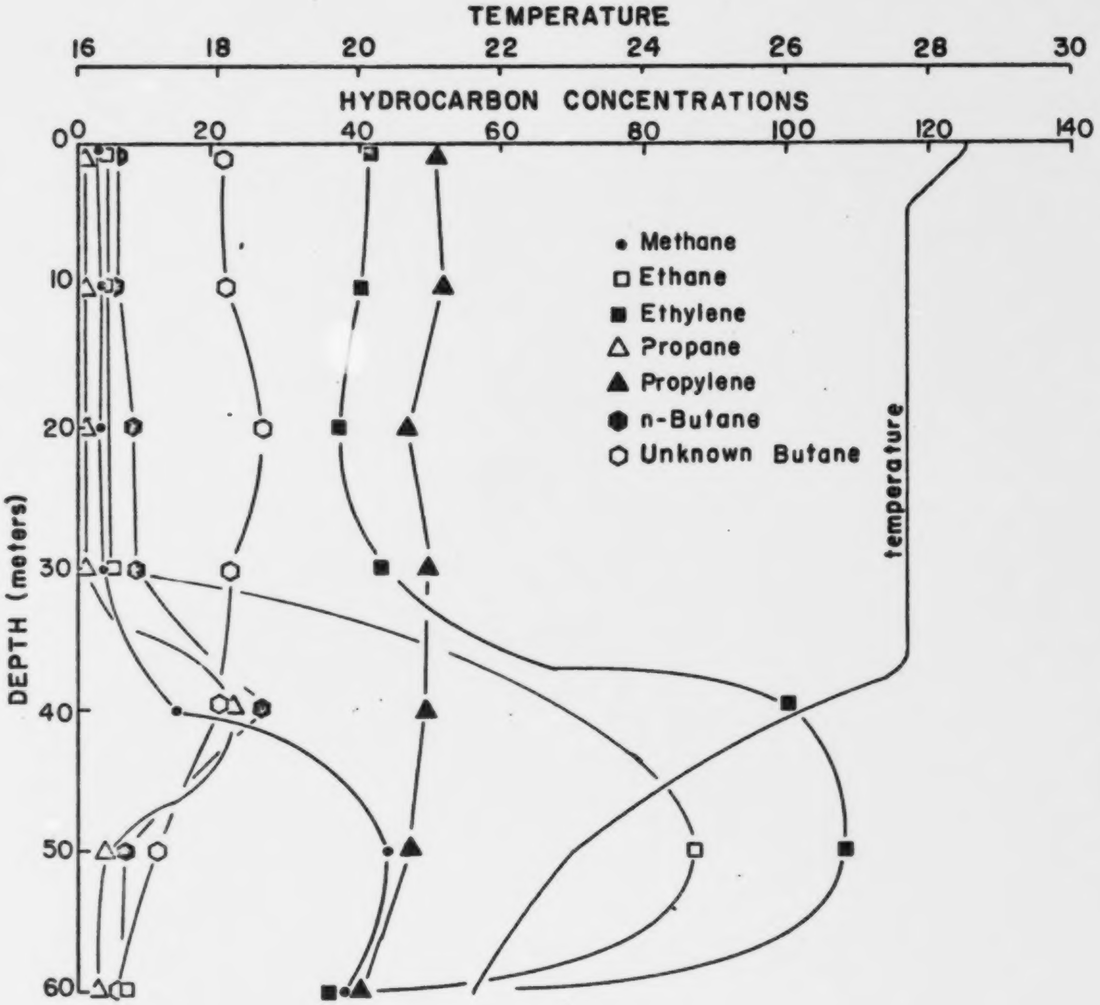


Fig. 9 Typical fathogram in which gas bubbles from a natural gas seep appear as acoustical reflections.

SWINNERTON METHOD
LOCATION: 28° 09.8N 91° 48.6 W
taken over gas seep (October 1973)



Methane x 10^{-5} ml/L
Ethane, ethylene, and propane x 10^{-7} ml/L
Propylene and butanes x 10^{-8} ml/L

Fig. 10 Diagram showing increased concentrations of hydrocarbons in seawater over a natural gas seep.

Some Problems Associated With the Collection of Marine Samples and Analysis of Hydrocarbons*

John W. Farrington
Woods Hole Oceanographic Institution
Woods Hole, Massachusetts

This report was prepared as part of a general research and assessment effort for "Quantification and Passive Tagging of Petroleum in Marine Organisms and Sediments", funded by Grant R-802724--Environmental Protection Agency, Oil and Hazardous Materials Branch, Edison, New Jersey; and by the Office for the International Decade of Ocean Exploration, National Science Foundation--Grant GX-35212. Additional funds for sampling cruises and initial analysis of samples were provided by the Office of Naval Research, NOOO 14-66 Contract CO-241 NR083-004, and the National Science Foundation, Grant GA-35646.

I wish to thank Mr. Gilbert C. Medeiros and Mr. Thomas Dorsey for their assistance in analyzing the sediment samples. I also wish to thank Dr. Max Blumer for his comments during general discussion of this topic.

Preface

I wish to state that my presentation reflects only my own viewpoints on this subject. Some scientists at the Woods Hole Oceanographic Institution, including me, are not happy with the practice of some government agencies and industrial organizations of formulating and referring to a "Woods Hole Oceanographic Institution position or method" based on the reports or papers of individual scientists working at the Institution. I ask those who read or hear this presentation not to make this mistake.

Introduction

During the past four years there has been a dramatic increase in the requirements of federal, state, local agencies, and industry to understand the inputs, fate,and effects of petroleum discharged to the marine environment. This resulted in the funding of laboratory studies, field studies, and literature surveys for environmental impact statements. This in turn resulted in a proliferation of primary scientific literature, technical reports, symposium volumes, and workshop reports. The number of printed pages from studies of oil spilled from tankers and offshore production accidents is very large. As a whole, they are probably typical of the literature in the field of oil pollution research;

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*This is Contribution No.2794 of the Woods Hole Oceanographic Institution.

they appear to be contradictory. However, because of their very nature, accidents are not predictable with respect to time or place. Most studies of the effects and fate of oil from accidental spills were forced to rely on expertise already on hand in the laboratories of the investigators at the time of the accident. This expertise was of varying applicability in answering the questions posed in studying the spills. This resulted in seemingly conflicting statements about the fate and effect of oil spills. This was, in part, due to the lack of sensitivity of some of the biological survey and analytical chemistry techniques, and in part due to the lack of intercomparability of some of the techniques employed. This was coupled with the problem that each oil spill and each intentional discharge of oil to the marine environment is, in some respects, unique. For example, the exact chemical composition of the oil, environmental factors such as temperature and suspended sediments, and the location of the spill will be variable (Straughn, 1972).

In order to make some sense of the literature to date, the National Academy of Sciences convened a workshop to review the literature and to evaluate its applicability to understanding the inputs, fate, and effect of oil in the marine environment. The final report is being reviewed. However, the background papers have been released and will shortly be available from the National Technical Information Service. These background papers offer an extensive coverage of the subject from the individual-author point of view.

It is clear from studies of the effect and fate of oil discharged to the marine environment that the availability of adequate information on the existing state of affairs before a spill or discharge occurred is essential to the full interpretation of the fate and effect of the discharge.

The present report is concerned with (1) the problems of obtaining samples and analyzing samples under conditions that avoid contamination, and (2) the use of precise and accurate analytical techniques that have been intercalibrated with other laboratories.

Sampling

The bulk of samples obtained in continental shelf waters will be taken from ships. From the point of view of the analyst who wishes to obtain marine samples for hydrocarbon analysis, a ship is a floating cloud of hydrocarbons which can contaminate samples. It is established practice on most ships to lubricate exposed gear to protect it from the corrosive marine atmosphere. Winch wires on which sampling gear are suspended are one example. The sampling team has the additional problem of reminding the officers and crew that bilge pumpings and sanitary tank pumpings should be secured before arrival on station and throughout the sampling operation. We have found that we obtain excellent cooperation of the officers and crew of the Woods Hole Oceanographic Institution research vessels if we explain in detail to them the scientific program and our problems with respect to contamination from the ships.

It is essential, nevertheless, to have available samples of all possible contaminants such as lubricating oil, ships' fuel oil, and paint for later analysis to compare hydrocarbons compositions of potential contaminants with the composition of hydrocarbons isolated from the samples. A review of sampling procedures used during the Baseline Studies Program of the International Decade of Ocean Exploration has been published (Grice et al., 1972).

As an example of some problems encountered in sampling, let us examine sampling for plankton. Net towing procedures used to obtain plankton samples often collect tar debris from the water column. Thus, analyses of plankton samples should be referred to as analyses of seston unless there is adequate examination of the samples under a microscope to insure that the sample is indeed only plankton (I.D.O.E. Baseline Studies Report, 1972). Further problems with net tows have been reported by Harvey et. al., (1972). They found that some nets absorb hydrocarbons from the water while being towed through the water. Transfer of hydrocarbons from the net to the plankton sample would introduce artifacts into the sample.

Controls for the Analysis of Marine Samples

It is essential that the analysis of samples be compared to the analysis of controls carried through the same extraction and analysis operations. This will establish whether or not artifacts are introduced from the solvents, reagents,and laboratory atmosphere during the analysis.

As an example, I will describe some problems we have had when analyzing water samples. We prepared very clean reagents and solvents for the extraction of sea water samples. We analyzed controls which went through all of the procedures we would use for the sea water samples and found that our controls showed negligible quantities of hydrocarbons--contributions less than 1.0 x 10^{-9} g/liter. We then went to sea and extracted water samples on board the R/V ATLANTIS II in the North Atlantic. We also ran control samples in the laboratory on board ship. The analysis of control samples showed that during the extraction procedure on board the ship our samples were contaminated by the ship's atmosphere. The concentration and composition of the hydrocarbons in the controls and samples were so similar as to invalidate the data for our samples.

Sample and Control Analyzed Simultaneously

Hydrocarbon Concentrations

A-II-71-1 Sample	Controls
5.4 µg/liter	4.1 µg/liter

To overcome this problem we designed, with the assistance of our colleagues, a portable laboratory which is now in the final stages of construction. This laboratory will essentially cut us off from the ship's atmosphere by filtering all the incoming air. The laboratory also contains a laminar flow hood providing us with a "clean" interior work area.

I have gone into detail on this point because there have been several papers published during the last year reporting analysis of hydrocarbons in sea water. Some of these papers make no mention at all of controls analyzed at sea, even though the samples were extracted at sea. Some papers state that controls were run in the shore-based laboratory or that concentration of the solvents used showed no contributions of hydrocarbons from the solvents. Our experience has been that a control analyzed in the same manner and in the same location as the sample is the only valid control.

Intercalibration

Hydrocarbons in marine samples have been analyzed by a number of laboratories employing different extraction procedures and using several different methods of analysis. This practice will probably continue in the near future. Comparison and integration of the results of analyses to obtain a coherent view of hydrocarbon distribution in the marine environment assumes that the interlaboratory and intermethod precision and accuracy allows such a comparison and integration. It is essential, and I cannot emphasize this point too strongly, that the analysts in the baseline and monitoring program for the Eastern Gulf of Mexico and other locations intercalibrate their analytical chemistry procedures and if possible, decide on a common method of analysis.

As far as I have been able to determine, the only intercalibration ever conducted for the analysis of hydrocarbons in marine samples was conducted by laboratories participating in the I.D.O.E. Baseline Program for hydrocarbon analyses. Some of the results of the intercalibration were published (Farrington et al., 1973) and the others are available in report form (I.D.O.E. Baseline Study Reports, 1972). During the last two years I have sent out samples of one reference material to sixteen laboratories. I received five replies containing data. Three of the five who replied failed to obtain concentration values and only reported relative percentages of hydrocarbons.

The participants in the intercalibration exercise (Farrington et al., 1973) viewed their exercise as only a first step toward further intercalibration efforts. There has been a large amount of talking about how essential intercalibration programs are to baseline and monitoring efforts. There has been very little action. As scientists I think that we can at least agree on this aspect of a program for the analysis of hydrocarbons in marine samples.

Analytical Techniques for the Determination of Petroleum Contamination in Marine Samples

Techniques for the analysis of petroleum hydrocarbons in marine samples have been reviewed elsewhere (Blumer _et al_., 1972; Farrington, 1973, among others,) and I will only point out some of the major difficulties. The detection of petroleum hydrocarbons in marine samples is complicated for two principle reasons. First, the analyst must distinguish between recently biosynthesized hydrocarbons and petroleum hydrocarbons in order to estimate petroleum contamination. This distinction can only be made by comparing hydrocarbons native to the marine sample with petroleum hydrocarbons to discern the characteristics of each group. Second, hydrocarbons in petroleum have such a wide range of molecular weight and molecular structure that no one method of analysis presently available provides an accurate assessment of total petroleum when considering all possible oil contamination incidents.

We have an idea of the chemical composition of petroleum because of the efforts which have focused on the analysis of petroleum over the past three decades. However, despite this effort there has never been a complete analysis, compound by compound, of a crude oil. The complexity of the mixture of chemicals, numbering at least into the tens of thousands, has defied the talents of the analysts to date. This fact, coupled with the discharge of many different crude oils and crude oil products to the marine environment, each with its own unique chemical composition, presents us with an analytical chemistry problem of some magnitude.

However, by concentrating on detailed analysis of isolated fractions of hydrocarbons we can obtain information useful to answering environmental quality questions. An example is the desirability of having detailed analysis of the aromatic hydrocarbons in petroleum and in environmental samples.

Our knowledge of hydrocarbons biosynthesized by organisms suffers in three areas. _First_, only a limited number of organisms from only a few geographical locations have been analyzed for their native hydrocarbons. _Second_, there have been relatively few analyses of cultures of microorganisms, other than phytoplankton, grown under conditions which would have precluded contamination by petroleum hydrocarbons from laboratory air or documented that such contamination did occur. This is an important point since the types of hydrocarbons biosynthesized by microorganisms such as bacteria, fungi, yeasts, and actinomycetes will have a great bearing on the techniques we will employ to detect low level petroleum contamination in marine samples, especially sediment and water samples (Farrington, 1973; Farrington and Quinn, 1973). _Third_, some of the past investigators have limited their analytical techniques in order to search for one or two types of hydrocarbons--usually n-alkanes, branched alkanes, and alkenes, and would not have detected other types of hydrocarbons if present. Only a few investigators have analyzed a limited number of marine samples for the various types of hydrocarbons (Blumer _et al_., 1971). Thus we have little information on the presence or absence of cyclic alkanes and especially aromatic hydrocarbons. These are the two types of hydrocarbons which appear at present to be the key to detecting low-level petroleum pollution in the marine environment.

There has also been very little attention focused on the analysis for the S, N, O heteroatom compounds in petroleum-polluted samples. These compounds should not be neglected since thiophenes, for example, might be responsible for some of the toxicity of oil towards marine organisms.

It is highly desirable to have samples or analyses of samples available from control areas free of petroleum pollution when analyzing samples to determine the extent and severity of a particular oil pollution incident. Unfortunately, there is no place in the ocean where petroleum-free organisms can be collected when considering the problem of detecting low levels of petroleum contamination. This points to the necessity of baseline data--i.e. existing concentrations and composition of hydrocarbons in an area such as the Eastern Gulf of Mexico--if the impact of oil exploration and oil production operations is to be effectively monitored and evaluated.

To illustrate this point I present the results of analyses of saturated hydrocarbons in surface sediment samples in the New York Bight area and the continental shelf to the east (Figure 1). The stations are located in relatively close proximity to each other considering the area of the continental shelf off the Middle Atlantic Region. The concentration of saturated hydrocarbons in the sediments is given with each gas chromatogram in Figure 2. Concentrations vary by about two orders of magnitude. It does not take an expert analytical chemist to look at the gas chromatograms and conclude that there is a good deal of variation in the patterns. This variation in gas chromatograms results from a variation in the chemical composition of the hydrocarbons in the sediments.

There are many sources for hydrocarbons in the sediments of this region. Large and small tanker accidents; industrial and municipal effluents; dumping of sewage sludge, harbor dredge spoils, and industrial wastes are among the many sources of petroleum hydrocarbons. The analyses of hydrocarbons in the sediments of this area have shown that a closely spaced sediment sampling grid would be needed to establish baseline concentrations and composition of hydrocarbons in sediments. If this data were not available it would be difficult to establish what the severity and extent of petroleum hydrocarbon inputs from offshore drilling and production might be if these operations were to begin in this area.

The application of the preceeding discussion to the Eastern Gulf of Mexico Region baseline assessment and monitoring is obvious and needs no further comment.

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Legends to Figures

Figure 1. Only Stations K-19-5-15, 16, 18, 20, and G 187DG, MG are pertinent to this report.

Figure 2. Gas chromatograms of saturated hydrocarbons isolated from column chromatography - Al_2O_3 (5% H_2O) over SiO_2 (5% H_2O), one column volume of pentane. Gas chromatograph column was OV-101 SCOT column of 25,000 effective plates (Perkin Elmer Corporation, Norwalk, Connecticut). The column was temperature programmed from 75° to 275°C at 6°/minute. Time axis is right to left in the figure with a chart speed of ½ inch/min. The numbers 17, 18, 23, etc. designate n-alkanes. Pr and Ph designate pristane and phytane, respectively. UCM designates unresolved complex mixture of branched, cyclic, and branched cyclic alkanes. X designates predominant, but unknown hydrocarbons resolved by the column. Concentrations are μg/g dry weight of sediment as determined by weighing the saturated hydrocarbon fraction from column chromatography.

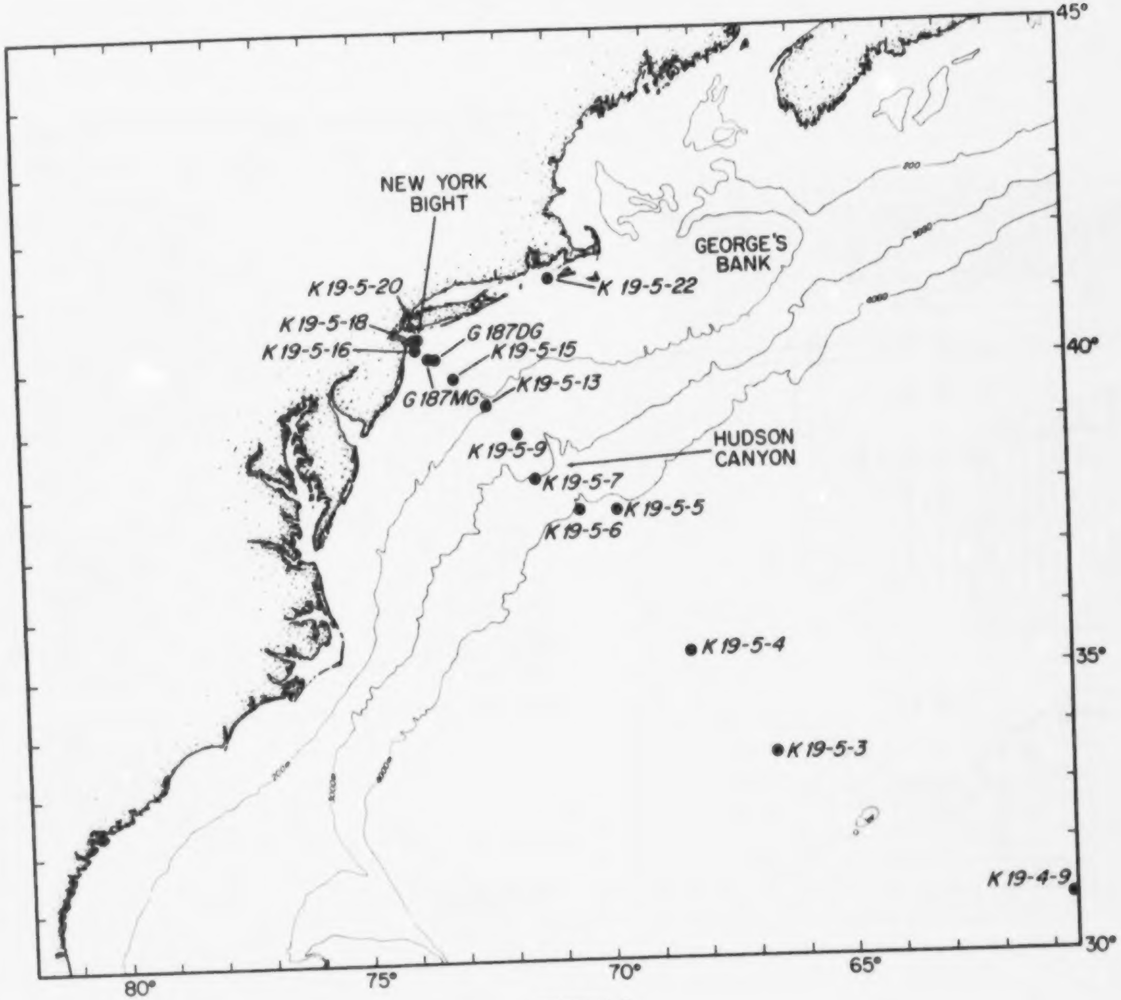
NEW YORK BIGHT
GEORGE'S BANK
HUDSON CANYON
K 19-5-20
K 19-5-18
K 19-5-16
G 187DG
K 19-5-15
G 187MG
K 19-5-13
K 19-5-22
K 19-5-9
K 19-5-7
K 19-5-6
K 19-5-5
K 19-5-4
K 19-5-3
K 19-4-9
45°
40°
35°
30°
80°
75°
70°
65°
200
2000
4000

FIGURE 1.

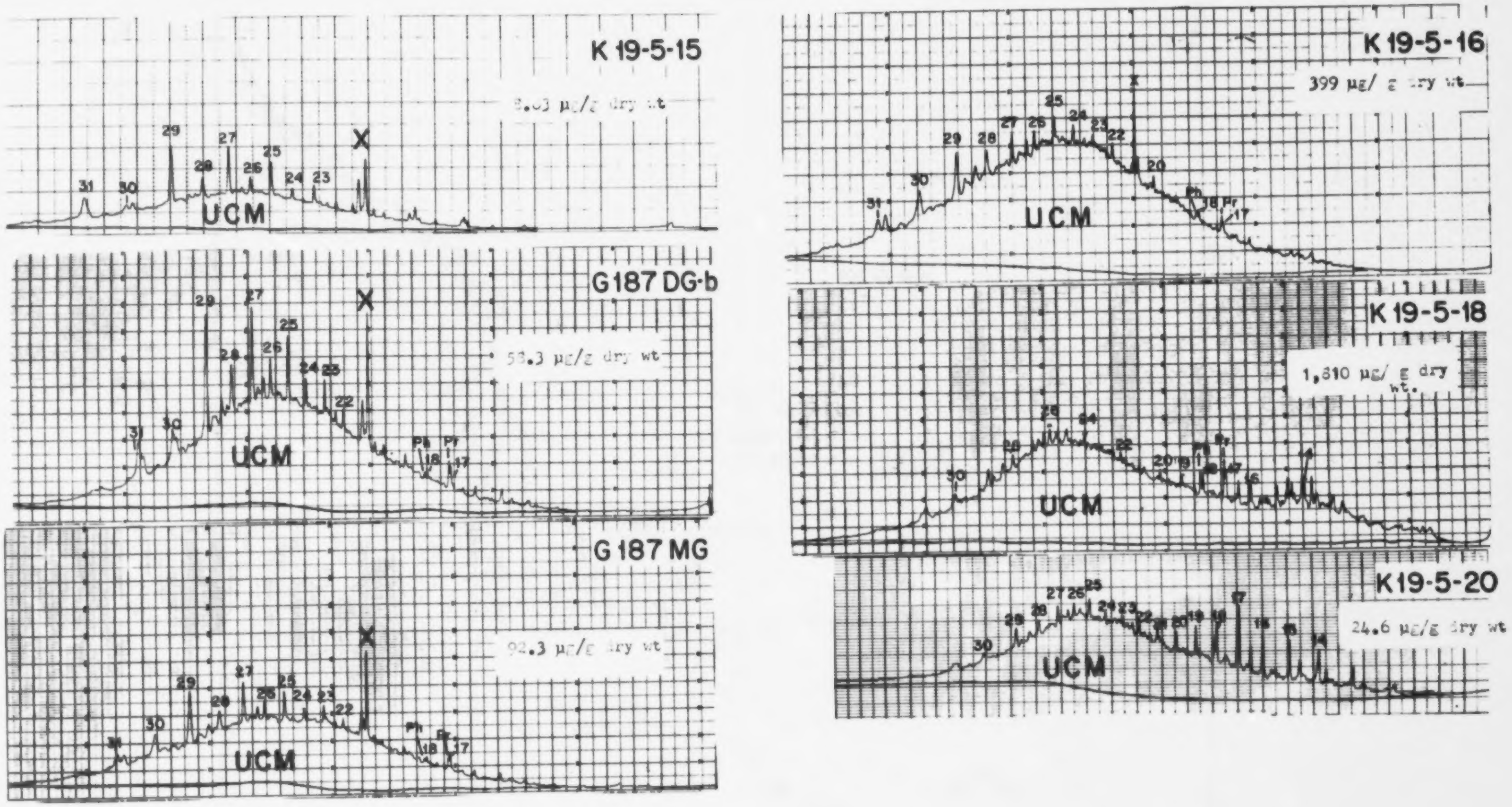
K 19-5-15
8.03 μg/g dry wt
31
30
29
28
27
26
25
24
23
X
UCM
G187 DG-b
58.3 μg/g dry wt
31
30
29
28
27
26
25
24
23
22
X
Ph
18
Pr
17
UCM
G 187 MG
92.3 μg/g dry wt
31
30
29
28
27
26
25
24
23
22
X
Ph
18
Pr
17
UCM
K 19-5-16
399 μg/g dry wt
31
30
29
28
27
26
25
24
23
22
X
20
Ph
18
Pr
17
UCM
K 19-5-18
1,810 μg/g dry wt.
30
26
25
24
22
20
19
Ph
18
Pr
17
16
14
UCM
K19-5-20
24.6 μg/g dry wt
30
29
28
27
26
25
24
23
22
21
20
19
18
17
16
15
14
UCM

FIGURE 2.

Experimental Design for an Environmental Program: Hydrocarbon Analysis in an Oil Producing Area

Patrick L. Parker
The University of Texas-Austin
Marine Science Institute
Port Aransas, Texas

Introduction

Marine scientists are being asked - ever more frequently - to explain how some modification of the environment will affect the marine ecosystem. This may seem, to many, a reasonable or even fortunate circumstance; in fact it is a circumstance for serious thought. These marine scientists must make judgments on impacted biological systems when their understanding of the fundamental operations of normal marine ecosystems is incomplete. Only by accelerating ocean research can there be any hope of assessing the effect of significant modifications of the marine environment on marine life and on man himself.

If successful, our discussions during this meeting will identify areas that need accelerated research, designate some general guidelines for environmental research and perhaps point to some priorities for research efforts.

I am one of those marine scientists who five years ago was trying to understand the natural marine carbon cycle. My first encounter with chemical pollution was an observation that the natural C^{13}/C^{12} variations of marine organic matter could be drastically shifted by petroleum pollution. Soon after this I became deeply involved in environmental affairs through participation in the NSF/IDOE Baseline Study of Pollutants in the Marine Environment. In this study my laboratory carried out a baseline study of petroleum in the Gulf of Mexico. After the Baseline study I spent a year at NSF/IDOE as Program Manager for Environmental Quality. My talk today will present some specific chemical data based on the IDOE study and make a few comments and observations based on my experience as a program manager.

NSF/IDOE Baseline Studies

The NSF/IDOE Baseline Program was known to be a one-year effort. For this reason our research on petroleum in the Gulf was designed to use measurements for which we were already tooled up. This meant we studied the distribution of normal paraffins in sea water, biota and sediment. At first we were concerned that paraffins, being the most biodegradable component of petroleum, might be too low to measure.

As it turned out there was plenty of paraffin for measurement and in a significant number of cases we were able to distinguish natural biosynthetic paraffins from petroleum-derived ones. The case where plankton with a known hydrocarbon composition had picked up petroleum and thus taken on a new hydrocarbon pattern was especially useful (Tables 1 and 2). It was felt that this type of observation could serve as a simple indicator of petroleum.

Although our sampling period was limited we were able to detect concentration gradients of paraffins dissolved in sea water off the north-central Gulf coast. Samples taken off Louisiana in an oil field in East Bay, while low in paraffin, were richer than samples taken 15 miles offshore of Corpus Christi, Texas, a control area. (East Bay 0.2 ppb n-paraffins vs 0.09 for Corpus). A burning offshore oil platform which had an oil slick associated with it allowed another study of concentration gradients. Samples taken five meters below the water surface contained 0.63 ppb n-paraffin two miles distance from the platfor, but only 0.16 ppb at three miles (Tables 3,4,5).

These data demonstrate that small quantities of petroleum-derived n-paraffins can be detected in marine biota and sea water. It is not known what fraction of the total petroleum present in the samples is represented by the normal paraffins, but one can estimate that the total might be at least 10 times the paraffin. Paraffins are low because they are the most insoluble and biodegradable components of oil.

Rationale for Marine Pollution Studies

I propose to look away from these rather detailed specific studies and ask what are the essential elements for a research program on marine pollution.

The overriding consideration for a marine pollution study is the health of the marine ecosystem. If adequately defined this includes human health. In order to learn whether a chemical or physical pollutant is harmful to marine life we must consider the following:

1. The chemical nature and concentration of the pollutant must be determined. This is the purpose of a baseline study which should be followed by a monitoring program.

2. The rates of actual and projected transfer of pollutants to the environment must be determined and the rate of decomposition or export of the pollutant measured.

3. The potential adverse effect on marine life of pollutants at environmentally realistic levels must be evaluated. This is the most difficult task because the natural variability of populations makes predictive models nearly impossible. Nevertheless key studies must be made at all levels of life -- biochemical, whole organism and complete communities.

Fortunately research supported by state and federal agencies is already underway for most of these elements. Perhaps in our discussions some of these on-going projects can be identified and related to the research needs which may be defined during this conference.

Problems of Experimental Design for Hydrocarbon Analysis in an Oil Producing Area

At last I come to the topic which was the title of my talk -- How to get good field-analytical data for hydrocarbons.

A substantial body of analytical data -- of high quality -- can be had for hydrocarbons in the eastern Gulf but it will require careful planning and heavy commitment by the active scientists. Fortunately, well-trained and interested marine scientists are available. Any study of hydrocarbons in the Gulf should involve two explicit assumptions. First, only measurements of the highest quality should be made even though this may be expensive in terms of manpower and modern analytical equipment. Second, the study should be carried out against the background of information commonly known as marine organic geochemistry. This means that effort should not be wasted re-discovering techniques and concepts that are common knowledge in oil company geochemistry laboratories and in several university laboratories.

I have listed what I believe to be the essential elements of such a chemical program. Some of these are of major concern, others less.

1. Qualified participating scientists agree to work together in order to attain stated goals.

2. Scientists agree to intercalibrate and standardize methods with regard to both an Eastern Gulf study and other national programs. In particular, standard petroleum samples must be agreed upon and should include various types, with the types found in the Gulf among them.

3. Participants recognize that the person doing the chemical analysis must go to sea and supervise sample collection.

4. Sampling must be frequent enough to meet the goals of the program. This may be often in the early stages of the program. A clean boat and great care are required.

5. Samples must include the biota and water. Sediment may be required in shallow water. Our experience suggests that plankton are better samples than higher organisms such as fish.

6. A complete chemical and, in some cases, isotopic characterization of the hydrocarbons must be planned for. This will include: total hydrocarbons; percent paraffins, aromatic and heterocyclics based on standard on standard silica gel elution chromatography;

identification and quantitative measurement of paraffins, selected aromatics and perhaps other compounds. This approach will require clean, well-equipped organic geochemistry labs. Infra-red and UV spectrophotometers, gas-chromatographs, and liquid chromatographs are the basic tools but gas-chromatographs coupled to mass-spectrometers (GC-MS) will be needed for some identifications.

7. Provision should be made for the participating scientists to meet regularly and for constant information exchange. A monthly progress report seems to be a workable way to do this. The chemical group should have a formal way to communicate with the larger group working on the total environmental problem -- especially with biologists who are assessing the biological effects of petroleum.

8. The participating scientists should meet after the first phase of the research is complete in order to assess the data and to make recommendations for future work. As soon as an adequate baseline is established and standard analytical procedures worked out one would expect the research to slow and be replaced by a more routine monitoring program. Such monitoring might measure a few key hydrocarbons in sea water and plankton as well as some simple integrative indicator of petroleum such as the C^{13}/C^{12} ratio of particulate matter.

Such a program of chemical research will work. It is generally true that chemists will deliver. Perhaps this is because they ask simple questions.

The biological questions are harder but they are the important ones. It is important for us to learn about the impact of oil on marine life. It is a real problem. Work in our laboratory has shown that vital functions such as photosynthesis by algae and development of eggs are adversely affected by environmentally realistic concentrations of water soluble aromatic fractions of petroleum (Tables 6 and 7).

The meaning of these and many other observations for the environment must be found.

Table 1 n-Paraffins and Isoprenoids in Trichodesmium e.*

Location	#1 off Port Aransas Texas	#2 off Bayou La Fousche Louisiana	#3 off Freeport Texas	#4 off Houma Louisiana
15	Tr	.3	.2	.4
16	2	1.2	.9	1.0
Pristane	--	Tr	.9	1.4
17	95	94.1	30.5	6.0
Phytane	--	Tr	1.4	1.5
18	1	.4	2.2	2.1
19		.4	3.2	2.4
20		.2	3.8	2.6
21		.1	3.9	2.3
22		.3	4.2	3.0
23		.2	4.7	2.7
24		.1	4.3	2.7
25		.1	4.9	3.6
26		.1	5.6	4.3
27		.1	4.7	4.3
28		.1	4.6	4.7
29		.1	3.8	5.3
30		.1	2.6	6.6
31		.1	1.6	6.3
32		.1	1.8	7.3
33		.1	1.9	6.5
34		Tr	1.8	6.1
35		Tr	2.8	9.7
36		--	2.4	6.0

* A planktonic blue-green algae.

#1 Several pure cultures of related blue-green algae contain very simple patterns similar to this.

Table 2 n-Paraffins in Sargassum sp.

	Clark*		Louisiana	
14	150	ppb	--	
15	4,610		9.7	% composition
16	190		.3	
17	570		7.1	
18	170		0.8	
19	130		0.7	
20	110		0.7	
21	81		1.0	
22	75		2.2	
23	100		1.6	
24	100		1.8	
25	150		2.5	
26	210		3.6	
27	300		4.3	
28	400		6.2	
29	460		8.6	
30	320		10	
31	280		11	
32	1		9.5	
33			7.6	
34			5.1	
35			3.0	
36			1.7	

* Clark, R. C. Jr. (1966) Occurrence of normal paraffin hydrocarbons in nature. Tech. Rept. Ref. No. 66-34, WHOI, Woods Hole, Mass.

Table 3 n-Paraffins in sea water

Sample	East Bay 1	652
Location	East Bay, La.	15 miles off Corpus Christi, Texas
Depth sampled	10 ft.	10 ft.
Total n-paraffins	.20 μg./l.	0.087 μg./l.
Percentage composition		
15	6.1	Tr
16	Tr	Tr
17	Tr	Tr
18	Tr	Tr
19	1.6	5.7
20	Tr	3.4
21	5.1	9.8
22	1.5	7.2
23	3.0	10.1
24	2.7	9.0
25	1.8	2.7
26	3.2	3.1
27	6.0	3.5
28	13.2	14.0
29	13.6	13.5
30	12.7	5.1
31	11.6	5.9
32	8.8	3.9
33	5.5	2.4
34	2.9	Tr
35	Tr	Tr
36	Tr	Tr

Table 4

A series of water samples were taken in the vicinity of a burning oil platform off Louisiana. The samples were taken at a depth of five meters. Sample OR2 was taken 300 to 400 yards from the platform in a direction 90° from an oil slick moving downwind away from the area of the platform. Sample OR3 was taken below the oil slick about 2 miles from the platform. OR4 was taken in the same general downwind direction about 3 miles from the platform. No apparent slick was present at OR4. The concentration and percent composition of n-paraffins in these samples are given in Table 5.

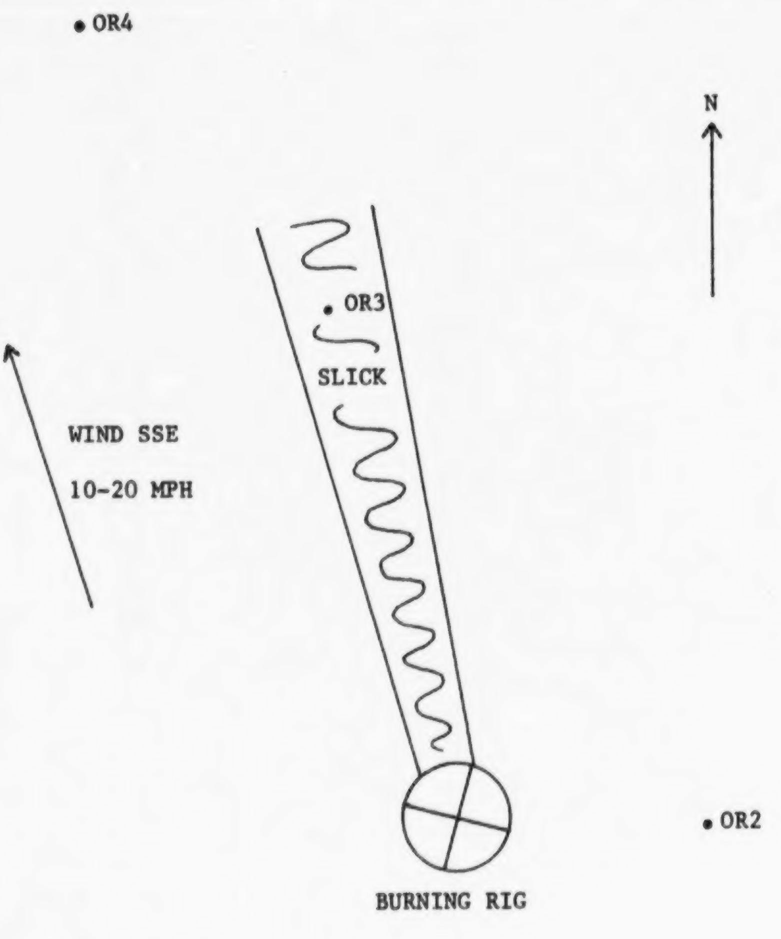

Table 5 n-Paraffins in Sea Water

Samples taken near a burning offshore oil platform, 17 November 1971, Lat. 28°39' Long. 91°30'.

Sample	OR2	OR3	OR4
Total n-paraffins	.25 μg./l.	.63 μg./l.	.16 μg./l.
FFAP Retention Index	%	%	%
1500	.9	1.4	10.3
1600	1.0	.5	2.8
1700	2.0	.8	4.6
1800	1.1	.5	4.5
1900	3.6	17.4	6.1
2000	2.7	1.3	5.7
2100	2.5	1.3	5.7
2200	9.8	4.2	4.9
2300	3.6	2.2	2.8
2400	7.4	5.6	4.6
2500	6.4	7.3	2.4
2600	12.3	8.1	1.7
2700	7.0	7.1	4.8
2800	9.0	8.8	10.0
2900	8.7	5.6	7.9
3000	8.6	5.8	5.3
3100	4.0	5.1	7.2
3200	2.2	4.3	2.5
3300	2.3	3.8	4.1
3400	3.9	3.6	
3500	1.0	2.6	
3600	Tr	2.7	

Table 6 (Van Baalen, Pulich & Winters)

Doubling Times (hours) of various microalgae grown in Sea H_2O equilibrated with #2 Fuel Oil. Numbers in parentheses are lag times in hours.

Strain Designation	Basal medium*	Sea H_2O control	Concentration of Sea H_2O equilibrated with #2 Fuel Oil (8:1 v/v)					
			0.05%	0.5%	5%	10%	25%	50%
PR-6	3.9	3.9	3.9	3.9	3.9(4)	3.9(7)	N.D.(72)	∞
MAC	6	9	9	9	9	9	9(10)	N.D.(96)
3H	7.8	7.8	7.8	7.8	7.8(24)	7.8(60)	∞	∞
Dun	6.3	6.3	6.3	6.3	6.3	6.3	6.3	N.D.(96)
Ind. 580	7.2	8.3	8.3	8.3	9.5(168)	∞	∞	∞
OBB	50	50	50	50	50(120)	50(170)	∞	∞

* PR-6 = *Agmenellum quadruplicatum* (blue-green), medium ASP-2 + B_{12}, temp. 39°, this laboratory.

MAC = *Nostoc* sp. (blue-green), medium Og10, temp. 39°, source (D.S. Hoare, U.T. Austin).

3H = *Thalassiosira pseudonana* (diatom), medium ASP-2 + B_{12} + B_1 + Na_2SiO_3. SH_2O, temp. 30°, source (R. Guillard, Woods Hole).

Dun = *Dunaliella tertiolecta* (green), medium ASP-2 + B_{12} + B_1, temp. 32°, source (R. Guillard, Woods Hole).

Ind. 580 = *Chlorella autotrophica* (green), medium ASP-2 + B_{12} + B_1, temp. 32°, source (R. Guillard, Woods Hole).

OBB = *Gymnodinium halli* (dinoflagellate), modified medium NH15, temp. 30°, source (B. Wilson, Texas A&M, Galveston).

Table 7

	Vitelline membrane		First cleavage			Second cleavage			Larvae	
	Present	Absent	Present		Absent	Present		Absent	Number	Development
			Normal	Abnormal		Normal	Abnormal			
Control	100	0	100	0	0	100	0	0	Excellent	Excellent
Kuwait 1:1	100	0	65	0	35	99	0	1	"	"
No. 2 Fuel										
1:50	100	0	100	0	0	100	0	0	"	"
1:25	78	22	67	0	33	85	5	10	"	Very good
1:10	5	95	23	31	46	3	32	65	Fair	Fair
1:5	1	99	3	23	74	0	2	98	Extremely poor	Extremely poor
1:1	0	100	0	0	100	0	0	100	None	None

Effects of petroleum oils on the development of sand dollar eggs. Critera used were presence of a vitelline membrane at ½ h after insemination, normal and abnormal first cleavages at 1 h, and normal and abnormal second cleavages at 1 ½ h. Samples, each of 100 randomly selected cells, were examined at a magnification of x80. Estimates of numbers of larvae and states of development were based on examinations of entire cultures 24 h after insemination. (Nicol & Donahue)

Geological Oceanography

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Geology - Introduction

Frank T. Manheim
Department of Marine Science
University of South Florida
St. Petersburg, Florida

Geological problems (and to some extent geochemical problems heard previously) differ in one respect from others we have heard about at the conference. This is particularly true of geologic structure. The difference lies in the known reservoirs of pertinent information that are not released because of competitive or other reasons. Most, but not all, such data are in oil company files. Some were utilized in the preparation of the governmental environmental impact statement for the MAFLA lease area.

In this situation a defensible point of view appears to be that if, for any reason, data cannot be exposed to the usual examination, criticism and purification in the crucible of public opinion - i.e., scientific publication - then for the present purposes they might as well not exist.

This matter is brought out so that no one - speakers or questioners or commentors from the floor - will feel hesitant, intimidated or embarrassed in bringing out data, points of view or needs that might be affected by some body of data that cannot be exposed.

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Structural Framework of the West Florida Continental Shelf and Recommendations for Further Research

Thomas E. Pyle
Department of Marine Science
University of South Florida
St. Petersburg, Florida

William R. Bryant and John W. Antoine
Department of Oceanography
Texas A & M University
College Station, Texas

Introduction

The purpose of this paper is to provide background information for scientists of many disciplines gathered to discuss possible impacts from oil and gas exploration and drilling on the west Florida shelf and adjacent areas. We have outlined the region's geologic and tectonic setting, emphasized the gaps and speculation involved in painting even this broad picture, and ended our discussion with comments on research needs and their applications to problems of environmental impact on the shelf. The text which follows is a slightly modified transcription of the oral presentation made during the conference.

Text

The west Florida shelf is part of a broad carbonate platform covering more than one quarter million square miles of the Yucatan Peninsula, Florida, and the Bahamas. Although the land is low and flat and the shelf exhibits little relief, this broad expanse is interrupted by a number of deep channels whose walls are among the steepest slopes on earth -- in some places steeper than 30°. Two of these very steep slopes are the Campeche and West Florida escarpments. Other prominent features of the region include a small Bahamas-type channel known as the Catoche Tongue, and a modified, somewhat atypical channel, the southern and northern Straits of Florida. Although the Florida platform may be structurally less complex than many areas, it is not really a flat-sided, geological layer cake.

Mesozoic and Cenozoic carbonates and evaporites form a southward-thickening pile of sediments that is at least 19,000 feet thick beneath Cay Sal Bank; these sediments may be 34,000 feet thick -- nearly twice the depth to which they have been drilled and sampled. Where it has been reached by the drill, the so-called "basement" beneath the carbonates is

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a patchwork of igneous, sedimentary, and metamorphic rocks ranging in age from 89 to more than 500 million years (Late Cretaceous to Cambrian and possibly Precambrian).

The South Florida Basin is composed of a thick accumulation of sediments. The northern boundary of this structural basin is the Middle Ground Arch, which may have supported reefs even 100 million years ago. The southern boundary of the basin is the complexly folded and faulted geosyncline of the Greater Antilles. This geosyncline probably extends southwestward to Yucatan and British Honduras.

What happens westward beneath the Florida shelf? No wells had been drilled there to give us details, and our first knowledge of the subsurface structure came from seismic refraction experiments which detected gross layering in the crust.

Well-data on land in South Florida, combined with extrapolations to the offshore layering, revealed by a marine refraction profile extending from Naples to the escarpment, provided our first evidence that deep horizons were upturned toward the west to form a basin rim. This rim probly tended at certain times (notably during the early Cretaceous) to isolate the South Florida area from the sea and led to the deposition of evaporites.

Several years after the publication of these refraction data, seismic reflection profiles across the West Florida escarpment gave us a more detailed picture of the nature of this rim. These profiles showed a dip reversal, or anticlinal structure, along the face of the escarpment. One profile extended from DeSoto Canyon southward to the Florida scarp and onto the Mississippi Fan. A small hill at the base of the scarp is thought to be a submarine levee associated with a deep-water continuation of the DeSoto Canyon. A wedge of sediments derived from the Mississippi River appeared at the southern end of the profile.

A series of profiles showed that the scarp-face anticlinal feature appears on nearly all crossings of the northern part of the escarpment. It seems to persist, though buried, through at least part of DeSoto Canyon.

Extrapolation of trends established by drilling on the western Gulf Coast plus limited sampling on the scarp suggests that the seismic records show a Lower Cretaceous "reef." (The word "reef" is placed in quotation marks to avoid arguments regarding the genesis of this feature.)

The same kind of structure can be observed on a profile running from Dry Tortugas to Jordan Knoll in the Straits of Florida. The southern end of the Florida Scarp is crossed midway along this profile. The scarp shows less relief here than in the north, but the "reef" is still apparent. Seismic and magnetic data indicate that Jordan Knoll was probably an atoll separate from the main "reef" and built upon an igneous foundation.

In portraying the "reef," I have deliberately jumped from the north to the south end of the scarp. There is good evidence that the 'reef' was once present between these areas, but it now seems to be missing between 24° and 27°N. This area is now characterized by topographic offsets, canyons, and slump blocks which suggest that the "reef" has been removed by faulting, erosion, or slumping. Such mass wasting of parts of carbonate platform margins may be rather widespread if we judge from recently published seismic studies of the Campeche Escarpment by Wilhelm and Ewing and by results of the Deep Sea Drilling Project in the Bahamas and Straits of Florida.

When we gather all the evidence and plot the results of many detached studies, it is apparent that the Gulf of Mexico was rimmed by reefs during Lower Cretaceous time, a little more than 100 million years ago. Along the West Florida scarp these shallow water deposits have subsided a total of 5,000 to 6,000 feet since that time. Conditions favorable to reef growth were reestablished during Paleocene time and, to a limited degree, in the very recent past and the present as well.

The structural framework of the Florida platform is little modified by the movement of underlying salt, so common in the western Gulf of Mexico. It is generally thought that the competency of a great thickness of limestone is sufficient to prevent displacement and upward migration of the less dense salt. However, some piercement structures have been found in DeSoto Canyon landward of the supposed carbonate platform margin. It has been suggested that erosion of part of the limestone overburden is responsible for the local occurrence of these structures in the canyon where seismic records show evidence of numerous cut-and-fill structures and long-term erosional activity.

Another interesting feature of this part of the West Florida shelf is the Destin Dome, which was the focus of extraordinarily high bids during the recent leasing. Antoine, and others, suggested a possible connection between this feature and magnetic anomalies indicative of an igneous intrusion at depth. Ray Martin of the U.S. Geological Survey (USGS) prefers the hypothesis that the dome is related to a nonpiercement salt swell.

I would now like to emphasize the broad gap, in both distance and knowledge, which lies between the Florida scarp, where we have just scratched the surface but do have some control, and the extensively and expensively drilled land areas. The subsurface of the hundred mile-wide shelf between these two areas is little known publicly. Very few seismic refraction profiles have been published, most of the available reflection profiles are useless, and high-resolution profiling has just begun.

Studies of the Florida shelf at one time had a "head start" due to work which dated back to Agassiz in the 1870's. Excellent bathymetric maps published by G. F. Jordan and Harris Stewart of the Coast and Geodetic Survey in the late 1950's were enhanced by the surface sampling work of Gould and R. Stewart, also in the 1950's For many reasons, this early lead was lost and many other shelves are now better known. At present, we have virtually no published information on the shallow subsurface structure of the shelf or on bottom transport phenomena.

With regard to shallow structure, two areas have been examined with high resolution profiles by McCarthy and Clingan (University of South Florida): a reconnaissance of the central shelf has been made, and a detailed study of Howell Hook in the southwest has begun.

A hint at the potential for surprises on this seemingly featureless shelf is provided by a number of seismic profiles north of Tampa Bay. These show sediment-filled sinkholes aligned in a 15 to 20 mile-wide zone off Pinellas County. Sinkholes are not unexpected in Florida, but then again, we might expect to find them nearly everywhere. We wonder if they are restricted to a narrow band as they appear to be from our limited data. If they are restricted, what is the reason? Are they areas of discharge of groundwater -- either fresh or saline? If so, is this a seasonal phenomenon related to rainfall and aquifer level? We wonder also if the sinkholes indicate potential instability in nearby lease areas from caverns that have not collapsed. Or, are they in reality excellent platform-sites because they have already collapsed and have thicker than normal sediment fill? What is the relationship of these features and any other offshore sinks and springs to fracture patterns mapped on land by Vernon? To answer some of these questions, we need to locate all the fractures and sinks by seismic methods, take vibracores, measure the engineering properties of the sinkhole fill, and determine the salinities of interstitial waters.

We think that another important question concerns the relationship of the filled sinkholes to submarine Mud Hole Spring, located off Ft. Myers Beach. The Mud Hole is being studied by Francis Kohout of the USGS. He found it to be saline (chlorinities of 19-20°/oo), hot (97°F) and apparently rich in trace metals. We have noticed that our sinkholes, Mud Hole Spring, and several "deep holes" reported by fishermen,all lie within a belt 10 to 40 miles offshore. Karen Steidinger of the Florida Dept. of Natural Resources has noted that this is the area where Gymnodinium breve occur regularly and sometimes develop into red tides. This coincidence and many other pieces of evidence have led my colleague Dave Wallace and me to suggest that submarine discharge through the sea floor may initiate or support red tide blooms. We obviously don't know what the vital factor is -- salinity, temperature, trace metals, sulfides, and organic matter are some possibilities -- but we do feel that the whole question of natural seeps must be examined in early phases of a baseline study of the West Florida shelf.

Another important area which has very definite practical implications concerns bottom transport of water, sediments, and any pollutants entrained in their flow. On a regional scale we need to map active areas of bottom scour and sand transport by means such as side-scan sonar. This application of geophysical techniques must be accompanied by physical and geological oceanographic studies including bottom-current measurements and the release of seabed drifters to determine residual drift and ultimate geographic fate.

In addition to studies of bottom transport, geophysical tools have application to a number of other disciplines -- especially if the various groups are aware of each other's existence and needs. Seismic profiles which reveal the positions of filled valleys are valuable to the archaeologist in the search for river sites inhabited at times of lower sea level. Magnetometer data have obvious application to the search for wrecks and munitions. Sonar techniques can detect gas bubbles associated with any hydrocarbon seeps and should be incorporated in any reconnaissance survey of background conditions. As a final comment, let me say that offshore drilling has already occurred in Florida and near reefs (near the Marquesas Keys), and part of our strategy should include an examination of these sites.

Bibliographies

Extensive bibliographies covering all aspects of marine geology and geophysics of the eastern Gulf of Mexico and adjacent areas may be found in the following reports:

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General and Geotechnical Characteristics of the Surficial Deposits on the West Florida Shelf

H. K. Brooks
Department of Geology
University of Florida
Gainesville, Florida

Introduction

The West Florida Shelf is a stable carbonate platform (Fig. 1). Subsidence to produce the Apalachicola Embayment occurred in Middle and Late Tertiary. At the same time broad upwarping produced the Ocala-Middle Ground Arch and the Marianna (Chattahoochee) Arch. The pattern of submarine rock outcrop is in relationship to these structures (Fig. 2).

The bottom is a rocky plain with a thin discontinuous layer of sediment. Off peninsular Florida at depths greater than 60 feet the sediments are largely biogenic whereas both clastic and biogenic sediments are found offshore from the panhandle of Florida and on the Alabama shelf. Sinkholes and springs are known to occur near shore (Brooks, 1973). The nature and frequency of karst features appear to diminish further offshore. There are rocky scarps offshore that are more frequent at certain depths. For example, the description of the "Three to Fives" fishing ground and the "Southeast Grounds" in the area of the Destin lease-blocks reads as follows "Irregular sand bottom. Many sharp dips and ledges of 3 to 5 fathoms in relief; coral and other invertebrate growth on the rock areas. The ledges are parallel to the 20 fathom contour" (Moe, 1963).

Natural seismic activity on the Florida Platform is negligible. Two earthquakes (1879 and 1900) of significant magnitude have been recorded in the area of the St. Johns River Fault Zone. The fault zones related to Tampa Bay and Charlotte Harbor apparently have not been active since Pliocene Time. Shaler's Line (Husted, 1972) that extends from Charleston, S. C. to the Apalachicola Delta has been active northward but there is no evidence in the topographic expression of the Middle and Late Pleistocene terraces that activity has occurred along the Gulf Coast.

Surficial Rocks

The physical parameters of the rocks outcropping offshore (Fig. 2) are comparable to those of the same age on land. It is anticipated that the early Tertiary limestones will have bearing capacities of 50

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to 100 tons/ft^2 or more and a friction factor for grouted pilings of 1.5 to 2.0 tons/ft^2. The Middle Tertiary clays and clayey sands will probably have bearing capacities of 15 to 30 tons/ft^2 with friction on driven piles of about one ton/ft^2 (these figures are with a safety factor of three). Late Tertiary and Quarternary deposits will be heterogeneous. They will range in character from very hard limestone to noncohesive sands and skeletal rubbles.

Sediments

Relic sand consisting of beach and dune materials occurs westward of the Apalachicola Delta (Fig. 3). On the West Florida Shelf recent and relic carbonate sediments form a thin, discontinuous veneer. They are largely biogenic and are noncohesive. A belt of algal and peletoid sediments, probably of considerable thickness, occurs in water 100 fathoms and less. The Florida Middle Ground is a relic reef from Pleistocene time upon which seven or more feet of worm, algal and coral growth has developed during the past 7,000 years.

Geotechnics

Because of the uneven nature of the upper rock surface and the extremely high bearing capacity of the rocks, point loading by gravity structures may be a problem. Driven pilings and grouted, drilled piers will provide excellent, safe support for the planned drilling and production platforms under conditions of loading, and under projected 100 year storm and seismic conditions that can be anticipated in the eastern Gulf.

The West Florida shelf is essentially a drowned karst plain. Sinkholes are known to exist though they are not extensively developed. Evidence suggests that sinkholes and caverns diminish in frequency offshore. Thus, cavernous conditions and secondary porosity detrimental to foundation conditions would not, in most cases, be a problem. Grouted piers and the bridging effect of the limestone would solve this condition.

In many places it may not be possible to bury the pipeline by the conventional jet sled. Hydraulic cutting heads may have to be utilized to cut trenches 3 feet and more into the rocky bottom. Chert boulders detrimental to dredging are believed to be largely restricted to the 'Big Bend' region.

Until such time as structures are planned in the areas where thicker accumulation of noncohesive carbonate sands are planned, liquifaction will not be a factor influencing design.

Recommendations

Geologists have been negligent in characterizing the bottom in relation to factors significant in ecological interpretation. This could be remedied by side scan sonar, shallow high resolution reflection and refraction seismic surveys, bottom photography and in situ penetrometer tests of the firmness, stability and thickness of the sediment. Sediment petrography and genesis are of secondary importance but more work needs to be done to interpret the changing habitat conditions that have occurred with the Holocene rise of sea level. Because of the difficulty of obtaining bottom samples of sediment and fresh rock, it is probable that shallow refraction data (that provides data on velocity through the underlying materials) can best be used to explore the physical properties of the surficial deposits. Some direct observation and sampling by diving will be essential.

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List of Figures

Figure 1	Physiographic divisions of the Eastern Gulf of Mexico. Note the lease-blocks (plotted in black) off Florida are on or near the 40 meter (20 fathom) contour. Modified from Bergantino, R. N., 1971.
Figure 2	Geologic Map of the surficial strata in the Eastern Gulf of Mexico. The major structures are labeled. The lease-blocks are along projected trends of the "down-to-basin-fault zones" plotted by Murray, 1961, with those off Florida being on the Mesozoic.
Figure 3	Bottom sediment map of the Eastern Gulf of Mexico compiled from various sources, esp. Gould and Stewart, 1955 and Ludwick, 1964.

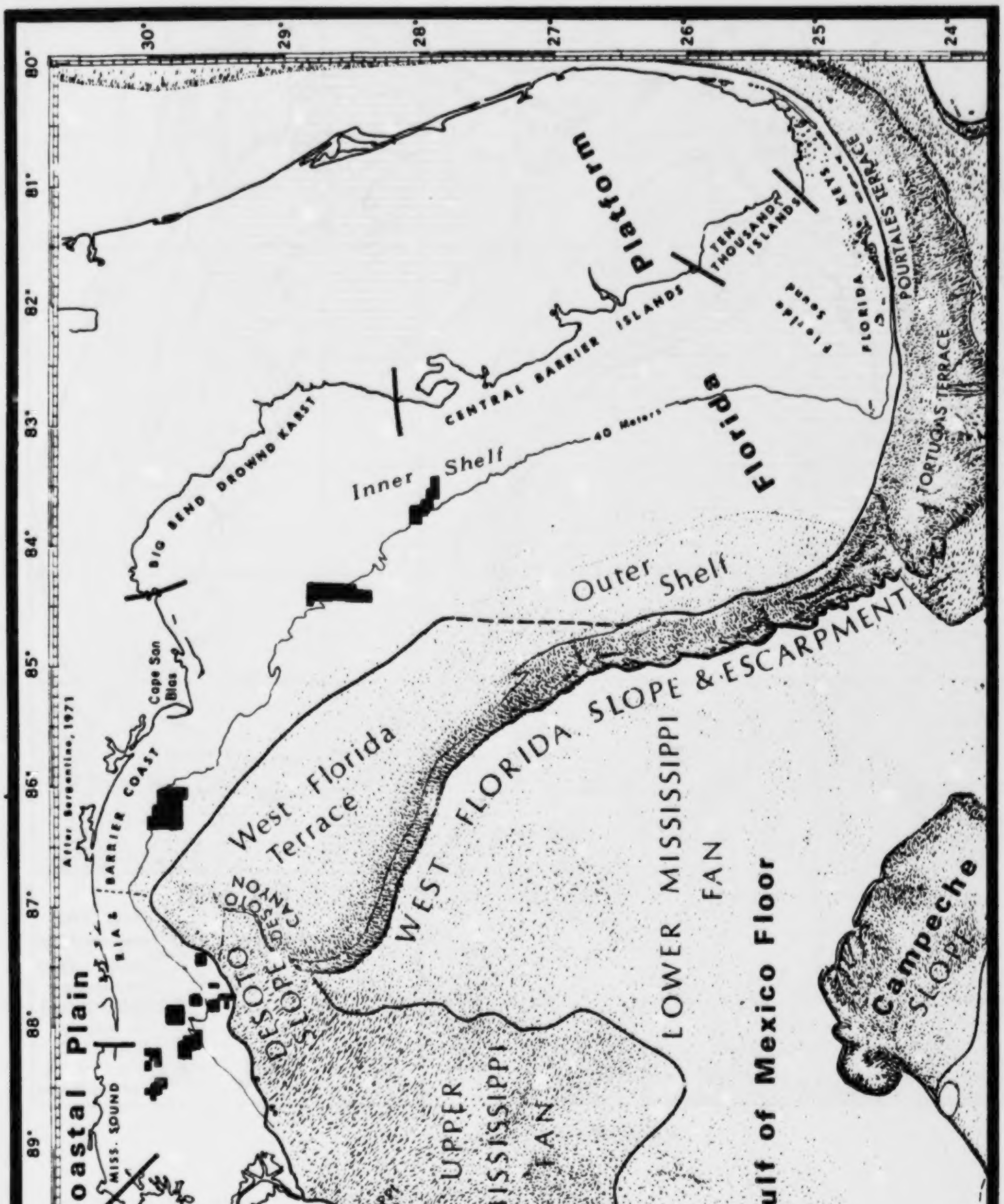
Coastal Plain
MISS. SOUND
RIA & BARRIER COAST
After Bergantino, 1971
Cape San Blas
BIG BEND DROWNED KARST
CENTRAL BARRIER ISLANDS
TEN THOUSAND ISLANDS
FLORIDA KEYS
Florida Platform
Inner Shelf
40 Meters
Outer Shelf
West Florida Terrace
DESOTO CANYON
DESOTO SLOPE
WEST FLORIDA SLOPE & ESCARPMENT
POURTALES TERRACE
TORTUGAS TERRACE
UPPER MISSISSIPPI FAN
LOWER MISSISSIPPI FAN
MISSISSIPPI TROUGH
DELTA
Gulf of Mexico Floor
Campeche SLOPE
89°
88°
87°
86°
85°
84°
83°
82°
81°
80°
30°
29°
28°
27°
26°
25°
24°

FIGURE 1

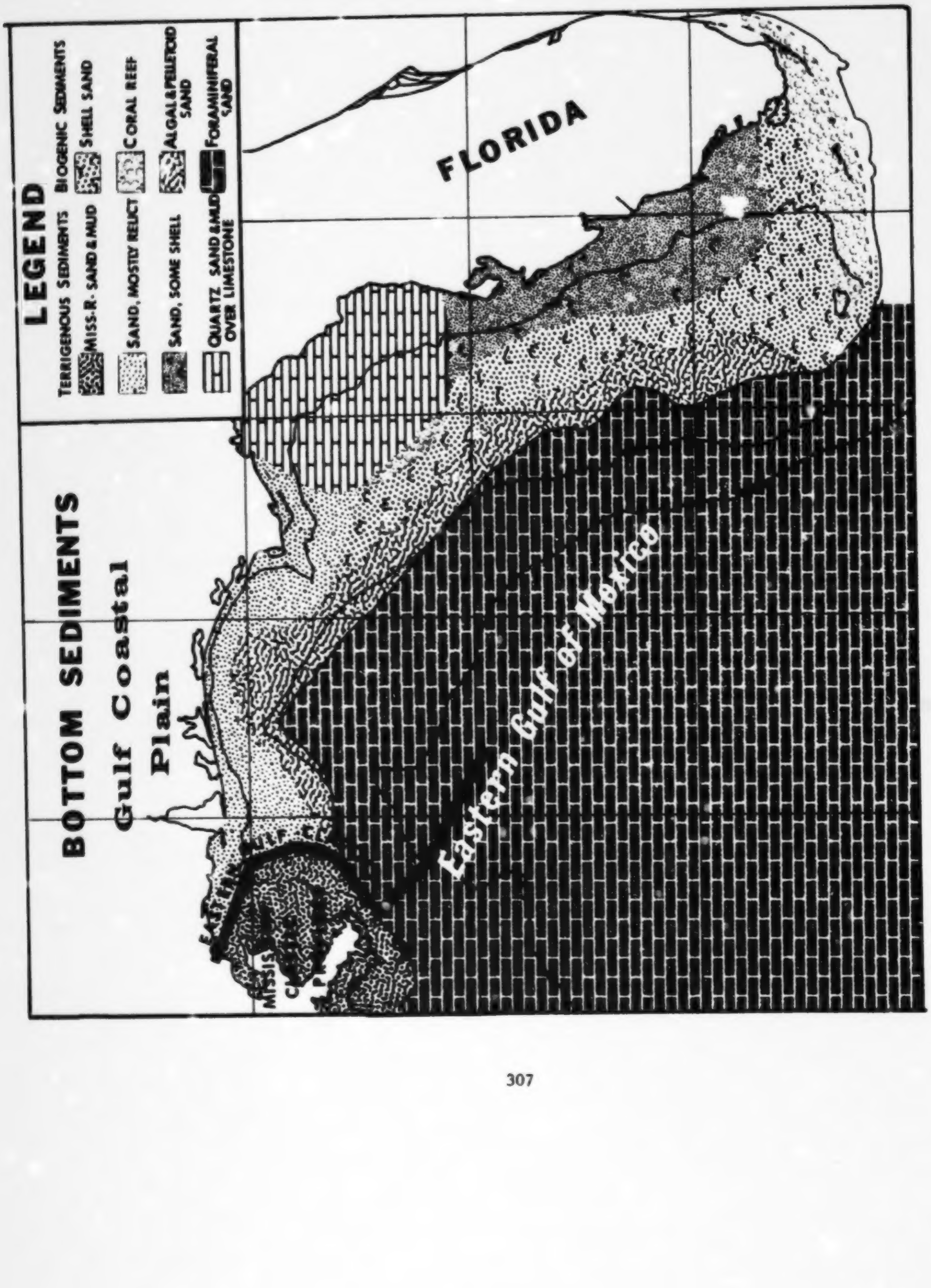
BOTTOM SEDIMENTS
Gulf Coastal Plain
LEGEND
TERRIGENOUS SEDIMENTS
BIOGENIC SEDIMENTS
MISS-R. SAND & MUD
SHELL SAND
SAND, MOSTLY RELICT
CORAL REEF
SAND, SOME SHELL
ALGAL & PELLETOID SAND
QUARTZ, SAND & MUD OVER LIMESTONE
FORAMINIFERAL SAND
FLORIDA
Eastern Gulf of Mexico

FIGURE 3.

The Coastal Sediment Transport System

William F. Tanner
Department of Geology
Florida State University
Tallahassee, Florida

The physical effects of petroleum industry operations can be put into two main categories: those which result from the operations themselves and those which arise from accidents. At the present, it is not known to what extent the operations themselves--though completely legal and even advisable--will affect the very delicately balanced sediment transport system which exists in the coastal and offshore zones. Furthermore, although the results of accidents can be foreseen in a general way, there is little information available on what an oil spill will do to the fragile low-to-moderate energy systems which exist along Florida's Gulf of Mexico shores.

The sediment transport system, a very sensitive one, merits further examination. The problem of beach erosion is very important in Florida, affecting perhaps 70 per cent or 80 per cent of the state's coastline. The best available evidence indicates that this problem can be expected to grow worse with time. Any near-shore activity that might aggravate the problem should be planned with extreme caution.

Beach erosion is a matter of sediment transport. This sediment is generally either sand or gravel; in Florida, beach erosion is due largely to sand transport. At the moment when transport begins, we have erosion; when sand transport stops, we have deposition. Transport usually connects two areas: an area of erosion and an area of accumulation (deposition). The areas of erosion and deposition and the transport path between them are described as one coastal cell. Coastal cells tend to be only a few kilometers long, or less, on very low energy sandy shores, and ten to a few hundred kilometers long on high energy sandy shores. A small sandy island offshore is, for example, characterized by two cells, one for each of the two littoral drift directions from the eroding seaward side of the island to the two ends or tips where deposition takes place.

An analysis of individual cells can be undertaken on the computer provided wave data and near-shore bathymetry are known. Dozens of cells, both small and large, have already been studied along the Gulf coast of Florida. These studies provide erosion and deposition rates at intervals along the coast of about one kilometer, as well as showing degree of leakage (if any) from one cell to another. At selected localities,

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historical studies of erosion and deposition have been undertaken to provide a check on the computer work. The results to date have been highly encouraging.

Dredging and filling modify the bathymetry and therefore produce additional sediment transport, which can be modeled on the computer. Because the computer's operational mesh is rather fine, and can be made even smaller, the effects of tiny operations can be studied in detail. Some very small causes, already studied, have had enormous effects--much larger than would have been predicted. In several instances, beach erosion or deposition has been modified greatly by a cascade process in which the original cause was magnified greatly by the waves themselves.

There are two important complications. First, sand is transported in a direction roughly normal to the beach as well as along the beach. This transverse, or "normal", transport is more difficult to predict, but progress is being made.

In a theoretical way we can state that any disturbance to the bottom, offshore, will set into motion certain changes that will tend to correct the effects of the disturbance. From studies in and close to the surf zone, where corrective action is extremely fast, it can be inferred that correction offshore, although somewhat slower, will still be relatively rapid. This correction should involve the movement of sediment, in many cases by wave action, so that the vertical profile of equilibrium will be established again. Those parts of the disturbed profile that are too high (too shallow) will tend to be lowered, and those parts that are too low (too deep) may tend to be raised.

The sediment transport to be deduced from these statements cannot always be obtained, however. In the first place, there are local slopes and geometrical irregularities which provide that the sense of transport will be seaward, regardless of the deformation of the equilibrium profile. In the second place, not all grain sizes and minerals respond in the same fashion, so that two different sizes, or two different mass densities, may be moved in opposite directions. In the third place, the bottom eddy system, which functions between the sediment surface and the deepest wave orbit, is oriented according to the wave ray azimuth, and this is not necessarily (and perhaps not even commonly) parallel with the line of the desired equilibrium profile. And, finally the interaction of bottom topography, waves, currents of several kinds, and sediment grain differences complicates the entire process greatly.

Along the Florida Panhandle shelf, as well as the shelf off the western coast of the peninsula, it is now known that sediment and geometry differences are pronounced, in some localities, over distances smaller than 100 meters.

The cascade effect, originating from very small features or disturbances, is responsible for local sediment concentrations that individually may reach volumes as great as 10^9 m^3. Transverse, as well as littoral, sediment transport plays a demonstrated role in building these accumulations. The reaction,or correction, time is very short. The system is delicately balanced. And we do not know which tiny input at one locality will cascade up to a major result at some other locality perhaps kilometers away.

The second complication has to do with the effects of additives (such as oil) to the transport system. In the case of sand, an oil spill may produce a coating on the beach, and wave action will convert the coated beach sand to "tar" pebbles. These soft pebbles are then moved in a way quite different from the motion of the original grains of beach sand. Unfortunately, we do not yet know a great deal about the endurance of an oil coating on a low-to-moderate energy beach, or the transport of such pebbles.

Furthermore the manufacture of tar pebbles is not the only concern. The Gulf coast of Florida is characterized by extremely great variability of wave and current energy levels. The spectrum of wave energy extends from no breakers at all, through "zero energy" shores having average breakers only a cm or two high, up to moderate or high energy coasts where the breakers average close to 50 cm in height.

Furthermore, although sand is a common coastal material in Florida, low-to-zero energy shores generally do not develop beaches. Instead, submarine meadows, marshes (covered by salt-tolerant grasses) and swamps (mangrove clusters) mark much of the state's Gulf coast. The effects of even a small oil skim on these low-to-zero energy shores, where wave activity is too small to make tar pebbles, is not now known, nor can it be predicted with assurance.

Analyses of the kinds outlined here can be undertaken for any area where wave data and bathymetry are available. However, wave data and bathymetry are typically of poor quality, and this fact restricts the usefulness of the technique in various coastal areas. Furthermore, transport of soft pebbles has not been studied yet, and controlled experimentation needs to be carried out on the effects of oil films on zero-energy beaches, submarine meadows, marshes, and swamps.

Therefore, new and better data need to be collected if the full potential of basic procedures is to be realized and if they are to be applied to the problems stated here. Additional historical information needs to be gathered to serve for further checking of the computer output, which is not perfect. Other methods of verification, including that work now possible with the scanning electron microscope and other sedimentological tools, need to be exploited, especially in areas where historical information is weak or nonexistant. Experimentation is needed on the effects of an oil spill on the marshes, beaches, and sediment transport systems at various energy levels. And finally, techniques of oil identification from very small quantities need to be calibrated so that oil masses can be traced to their sources, whether spills or natural seeps.

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PREPARED STATEMENTS
FOR THE
PROCEEDINGS

The conference/workshops could not be programmed whereby each discipline, ranging from socio-economics to oceanography, could be addressed during the sessions. Therefore, participants were invited to prepare statements to share this information and/or their comments with the readers of the proceedings.

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The Physical Characteristics of the West Florida Estuarine Gyre, with Notes on the Distribution of Selected Plankton During May 4 - 11, 1970

Herbert M. Austin
New York Ocean Science Laboratory
Montauk, New York

Introduction

Most oceanographic studies pertaining to the eastern Gulf of Mexico conducted during the late forties and early to mid-fifties were those initiated by the Fish and Wildlife Service (now National Marine Fisheries Service). These were primarily directed toward an examination of the red-tide phenomena, and the major center of emphasis was the West Florida Shelf.

Physical oceanographic studies rarely attempted synoptic observations, and most biological studies included few, if any, physical measurements. Some studies (Smith et al., 1951) were based on examination of climatological hydrographic charts (pilot charts). These early studies did, however, delineate regions of convergence and divergence.

King (1949) noted major differences between the planktonic assemblages on the shelf and those found in open Gulf waters. He noted that the shelf waters supported a substantial biomass but were low in diversity, whereas the pelagic waters, while lower in biomass, exhibited a more diverse fauna. Pierce (1952) found that it was possible to differentiate between West Florida Shelf and open Gulf waters based upon the predominant species of Chaetognatha collected.

Chew (1955) defined the physical water masses in the eastern Gulf of Mexico as the Gulf Loop Current, the Florida Bay Waters, the Florida West Coast Estuarine Water, and the Mississippi Estuarine Water. These he separated on the basis of their temperature and salinity relations and inferred flow patterns, and on the basis of data in Hydrographic Office charts.

History of the Present Study

The most recent studies in this area, many of which are still unpublished, have dealt with the distribution of larval fish, bulk plankton, and the tidal periodicity of the observed physical phenomena. These studies have been initiated by the Florida Department of Natural Resources

(DNR) and by the State University System of Florida Institute of Oceanography (SUSIO). Studies deriving from the interrelated physical and biological data generated by the State University System have shown that the northern West Florida Shelf is a far more dynamic region than had been imagined. This has become increasingly clear as a result of the snyoptic multi-ship oceanographic series designated EGMEX (Eastern Gulf of Mexico; Rinkel, 1971). To date EGMEX has generated six multi-ship operations, each so designed as to permit an examination of the interrelationships between the physical-chemical features and the biota. The data discussed here are from the first EGMEX cruise, conducted in May 1970.

Methods

EGMEX I was conducted in two parts (Austin, 1971; Rinkel, 1971). The first part consisted of a rapid 3-day survey of the distribution of temperature and salinity in the eastern Gulf, using salinity-temperature-depth (STD) probes or bathythermographic and hydrographic bottle casts. The second part, commencing a day after the termination of leg one and lasting five days, consisted of measurements of the temperature and salinity, the collection of water samples for trace-metal analysis (using Niskin nonmetallic water samplers, and the collection of zooplankton. As a result of at-sea analyses of the first part, it was possible to relocate the transects and stations for the second part, which permitted a sampling pattern relevant to the known distribution of temperature and salinity.

The Northwest Florida Shelf was sampled by the Department of Natural Resources research vessel, R/V HERNAN CORTEZ. The stations were reoccupied during the second part of the cruise, permitting an examination of the short-term changes that occurred in the physical water structure during the three days between the start of the first and the second samplings.

The R/V HERNAN CORTEZ used a CM^2 salinity-temperature-depth probe with an accuracy of ± .05° C for obtaining surface and vertical temperature data. Surface salinities were determined by titration. Vertical temperature data were collected only during the first half of the cruise and zooplankton only during the second.

Mixed-layer and sub-thermocline zooplankton were collected with a 1M diameter opening plankton net with a 605 μ mesh body and 295 μ mesh cod end. Tows in the mixed layer were step-oblique from the thermocline to the surface in five steps and sub-thermocline tows were horizontal; all tows were of 30-minute duration.

In the laboratory, displacement volumes were measured on all samples. These measurements were made by recording the volume of the sample and the preservative. This was then filtered through a 202 μ mesh cone-filter and the resultant liquid volume recorded. The difference between the two volumes was the volume of the sample.

The volume of water filtered was calculated from the following formula:

$$M^3 = \frac{\pi D^2 L}{4}$$

where: M^3 = volume of water filtered, in cubic meters
D = diameter of the net, in meters
L = distance of the tow, in meters

and: L = RT = the speed of the vessel times the duration of tow in minutes

where: R = rate = 2 knots (2 nautical miles/hour or 3706 meters/hour)
T = time = 5 to 35 minutes (depending on station)

Zooplankton biomass, the measured displacement volume/calculated volume of water filtered, was expressed as ml/M^3. Samples were split in a Folsum plankton-splitter to either 1/4 or 1/8 aliquots and the pteropods and sergestids removed. Counts were made on the individual species and the data expressed as standing crops (number/1000 M^3).

Where possible, field data from the R/V PILLSBURY AND R/V ISLAND WATERS were included from the May 7-11 biological-chemical survey. These data, plotted in figures 4-7, allowed a broader interpretation of the results.

Results and Discussion

First Half

The distribution of sea surface temperatures and salinities (Fig. 1) during the first half suggests the presence of waters from three different sources. Warm ($\geq$23°C), high salinity (> 35.00 °/oo) waters to the west are derived from the Eastern Gulf Loop Current (Chew, 1955; Austin, 1971); warm (> 23°C), low salinity waters to the east are inshore coastal estuarine waters; and the cool ($\leq$22°C) waters in the center of the area are either the result of upwelling, the advection of cool bottom waters into the region, or a combination of the two.

Examination of the vertical sections (Fig. 2) shows the presence of cool ($\leq$ 19°C) water in/over the shelf edge and Fig. 3 suggests that these waters are coming from under the northeastern boundary of the Loop Current. Upwelling into this region from the Loop Current has been documented in the past by Chew (1955) and Austin (1970). Neumann and Pierson (1966, p. 459) point out that, "A dynamic treatment of the upwelling phenomenon has to consider the fact that with stationary conditions cooler temperatures in the top layer are also produced by simple geostrophic adjustments of the field of mass to the field of currents. Cool water from deeper layers is lifted upward on the left-hand side of a current in the Northern hemisphere, and on the right-hand side in the Southern hemisphere, when one is looking in the current direction." The configuration of the isotherms and isopleths in Figure 3 leaves little doubt as to the presence of the southward flowing Loop Current along the edge of the shelf, which lends support to the concept of upwelling.

The analysis used here of inferred current patterns from the distribution of temperature and salinity is explained by Sverdrup, Johnson and Fleming (1942, p. 504). Interested readers are referred to this reference for a more detailed explanation. This explanation does not, however, entirely account for the configuration of the surface isotherms and isohales (Figure 1) nor the slope of isotherms (Figure 2) near the coast, nor does it explain their relation to the cool surface waters. Haight (1942) and Hollman & McGuire (1973) have shown how the effects of surface wind-stress influence the surface distribution of conservative properties in the region of St. Johns,Florida and the New York Bight. The mean wind velocities at St. Andrews State Park, St. Marks, and MacGill AFB, Florida, during this period (May 4-6) were easterly at 8-12 knots (4 to 6 m/sec.).* This is of sufficient magnitude to generate a wind-driven current to the north (off Tampa) and west in the Big Bend region (St. Marks), and hence to produce the isotherm/isohale configuration observed. Offshore in the survey area, winds were easterly at 10-20 knots (5 to 10 m/sec.) on May 4, increasing to 15-30 knots (7 to 15 m/sec.) from the northeast on the 5th. On the 6th the winds diminished.

It appears then that the cool water "pocket" present on the West Florida Shelf during May 4-6 was the result of both geostrophically balanced upwelling to the west and a wind-generated current along the east.

Second Half

The changes encountered in the distribution of surface temperature and salinity between the first (May 4-6) and second (May 7-11) halves of the cruise were pronounced,and demonstrate the temporal framework within which one must work in coastal systems.

It is apparent from the configuration of the surface isotherms that by the period of the second sampling (May 7-11) an anticyclonic eddy had split off from the Loop Current (Figure 4) and was moving in over the shelf, pushing the "tongue" of cool (22°C) higher salinity (>35.00 °/oo) waters on the central shelf further to the east and north, closing it off and creating a cyclonic eddy. The effects of these eddies on the distribution of salinity are apparent in Figure 4 as the southern flow between them transported lower salinity (<34.00 °/oo) nearshore waters out onto the shelf.

Mean coastal wind velocities recorded during the second leg remained easterly at 8-12 knots, providing a continuing mechanism for a wind-driven current along the coast. Offshore they were light and variable.

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*All meteorological data are courtesy of the National Weather Service, NOAA, Dept. of Commerce, Ashville, N. C.

Analyses of the physical data alone allow a delineation of the West Florida Estuarine Gyre and its inferred current patterns. The waters of the Gyre could also be characterized faunistically, and the inferred circulation patterns observed in the distribution of selected planktonic taxa.

Six species of Thecosomata pteropods were collected from the near-surface waters of the Gyre, whereas 12 were reported from the adjacent Loop Current during the EGMEX I cruise (Austin, 1971); one of two species of sergestid shrimp, *Lucifer faxoni*, was also taken (Cruise, 1971).

The pteropod *Cresis virgula conica* was the most common species taken from the mixed layer at all stations except at stations 13, 25, and 26, where no pteropods were collected. This species is typical of coastal or neritic subtropical waters (Myers, 1967; Austin, 1971). During the EGMEX I series, Austin found it to be diagnostic of coastal waters (e.g., Campeche Banks and West Florida Shelf), and its presence in pelagic waters was explained by its being entrained into a biologically productive mainstream flow.

Its distribution in the mixed layer here (Figure 5) is indicative of the current patterns described previously. A "tongue" of higher standing crop ($> 1000/1000$ M^3) is carried southward between the two eddies and out into the mainstream Loop. Their paucity ($< 100/1000$ M^3) within the anticyclonic eddy is explained by the fact that they are not abundant in the "Central Loop Waters" from whence the eddy was derived.

Their absence from stations 13, 25, and 26 is due to the fact that the waters at these stations were derived from an estuarine source which does not support pteropods.

Sub-thermocline water (20-30 m) supported a different, more varied, population. Of particular interest are the deeper tows at stations 17, 20, and 22. Here, in addition to *C. v. conica*, were *Limacina trochiformis*, *L. inflata*, *Styliola subula*, and *Peracles* sp. None occurred in any abundance except at station 22 where *Limacina inflata* constituted 68 per cent (93/1000 M^3) of the population. This particular species composition is very similar to that reported by Austin (1971) as characteristic of "Loop Transition Waters" or "Eastern Gulf Waters." A variation from Austin's faunal characterization is the complete absence of Foraminifera species from these collections. This is due to one or both of two factors: the mesh sizes used were too large (Foraminifera are normally taken in 200 μ mesh), or the formaldehyde was too acidic, resulting in the dissolution of the carbonate tests.

The presence of *Peracles* sp., a deep-water (100-200 m) pteropod (Austin, 1971; Williams, 1972), in these deeper tows suggests that upwelling was occurring or had recently occurred, which supports the earlier hypothesis for upwelling along the Loop border at the shelf slope.

Cruise (1971) reported the Gulf distribution of *Lucifer faxoni* and *L. typus*. She found that *L. typus* was pelagic, being the only species taken in the "Central Gulf Loop Waters" and Caribbean. L. faxoni, on the other hand, was only taken from outside the Loop Current and was most common in shelf waters. Kelly and Dragovich (1967) found that L. faxoni was one of the most abundant pelagic crustacea in Tampa Bay. Hela (1956) reported that a plume of low salinity waters, traceable to Tampa Bay, flowed northward along the Florida west coast. It was in this region that the greatest concentrations of L. faxoni were encountered during EGMEX (Figure 5), suggesting that Tampa Bay waters (during periods of easterly winds) flow to the north along the eastern boundary of the Gyre.

A secondary concentration of L. faxoni was observed in the south flow of the eddy discussed earlier.

The total zooplankton biomass, expressed in milliliters of plankton per cubic meter (ml/M^3), taken during this study is shown in Figure 6. Surface concentrations were high (≤ 0.30 ml/M^3) in the coastal waters east of the Gyre, and in the Loop Current axis to the west but low in the region of the Central Gyre (< 0.10 ml/M^3). The shoreward impingement of deeper-water (20-30 m), higher plankton concentrations from the sub-thermocline waters is apparent as concentrations move in over the shelf in the region of station 29, which follows the change in the salinity patterns (Figures 1 and 3).

A correspondingly high planktonic concentration should have been expected in the higher salinity surface waters in/over the shelf but was not found. The pteropod distribution suggests that the reason was that there were Eastern Gulf Waters which were lower in plankton than the Loop Transition Waters seen in Figure 6.

Water Masses and Inferred Current Patterns

From the distribution of temperature, salinity, and plankton it was possible to define the water masses and infer current patterns on the West Florida Shelf. For the May 4-6 "first half" these are shown in Figure 7, and for the May 7-11 "second half" they are shown in Figure 8.

The dominant surface feature during the May 4-6 leg was the Gyre and the Loop Current boundary. At 20 meters the central area of the Gyre was displaced to the north and the circulation patterns were not as clearly defined. Further offshore, however, the Loop boundary was clearly defined and the existence of a subsurface eddy or perturbation was noticeable. Similar subsurface features were documented in this region of the Loop Current by Austin (1971, pp 176-182).

During the period of the second half (May 7-11), the surface features were complicated by the presence of an eddy of Loop Current origin. Although no water column physical data were available, the pteropod distribution discussed earlier, and the distribution of the deeper plankton biomass suggest that the perturbation at 20 meters had moved from west of the shelf to a position south and west of the Gyre and in/over the shelf (Figure 8).

Other plankton organisms, notably chaetognaths and copepods, have also been demonstrated to be excellent indicator organisms. An examination of their specific distribution from these samples should also yield data on current patterns and, more importantly, the source of the water at any given point.

These distributional studies, when correlated with the distribution and abundance of pelagic fish eggs and larvae, will provide a means of establishing the planktonic migration pathways of commercially and ecologically important finfish.

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List of Figures

Figure 1 Distribution of Sea Surface Temperatures and Sea Surface Salinities during the first half (May 4-6, 1970) of the EGMEX-70-I cruise series.

Figure 2 Vertical distribution of temperature along the northern and southern legs of the first half (May 4-6, 1970) of the EGMEX-70-I cruise series.

Figure 3 Distribution of temperature at a reference depth of 20 meters during the first half (May 4-6, 1970) of the EGMEX-70-I cruise series; distribution at the depth of the 22°C isotherm during the first half (May 4-6, 1970) of the EGMEX-70-I cruise series.

Figure 4 Distribution of Sea Surface Temperatures and Sea Surface Salinities during the second half (May 7-11, 1970) of the EGMEX-70-I cruise series.

Figure 5 Distribution of the pteropod *Cresis virgula conica* and the sergestid shrimp *Lucifer faxoni* from oblique tows within the mixed layer during the second half (May 7-11, 1970) of the EGMEX-70-I cruise series.

Figure 6 Distribution of plankton biomass (ml/M^3) from oblique tows from within the mixed layer, and below the thermocline, during the second half (May 7-11, 1970) of the EGMEX-70-I cruise series.

Figure 7 Water masses and inferred current patterns at the surface and at the 20 meter reference depth during the first half (May 4-6, 1970) of the EGMEX-70-I cruise series.

Figure 8 Surface water masses and inferred current patterns during the second half (May 7-11, 1970) of the EGMEX-70-I cruise series.

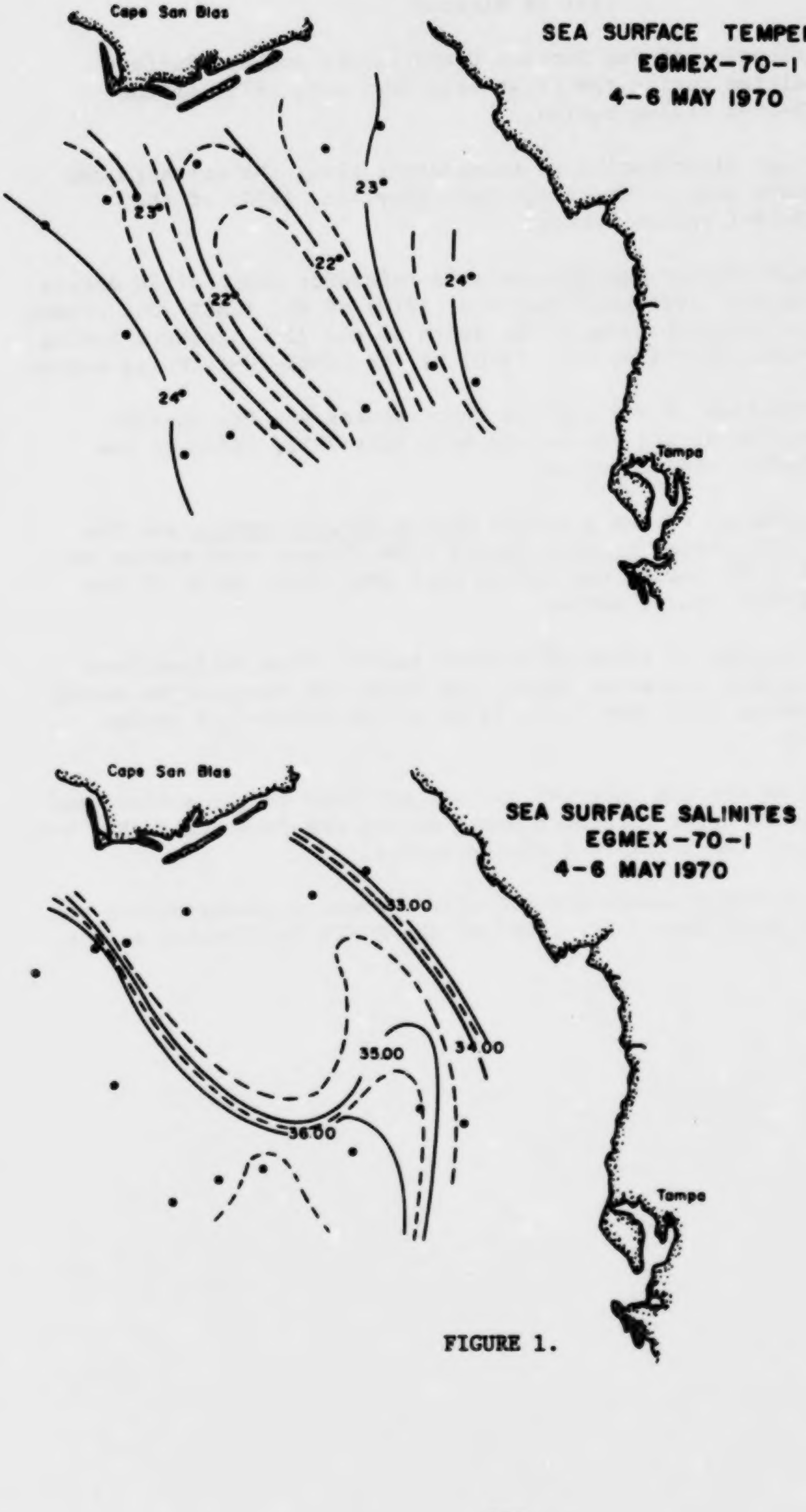

Cape San Blas
SEA SURFACE TEMPERATURE (°C)
EGMEX-70-1
4-6 MAY 1970
23°
23°
22°
22°
24°
24°
Tampa
Cape San Blas
SEA SURFACE SALINITES
EGMEX-70-1
4-6 MAY 1970
33.00
34.00
35.00
36.00
Tampa

FIGURE 1.

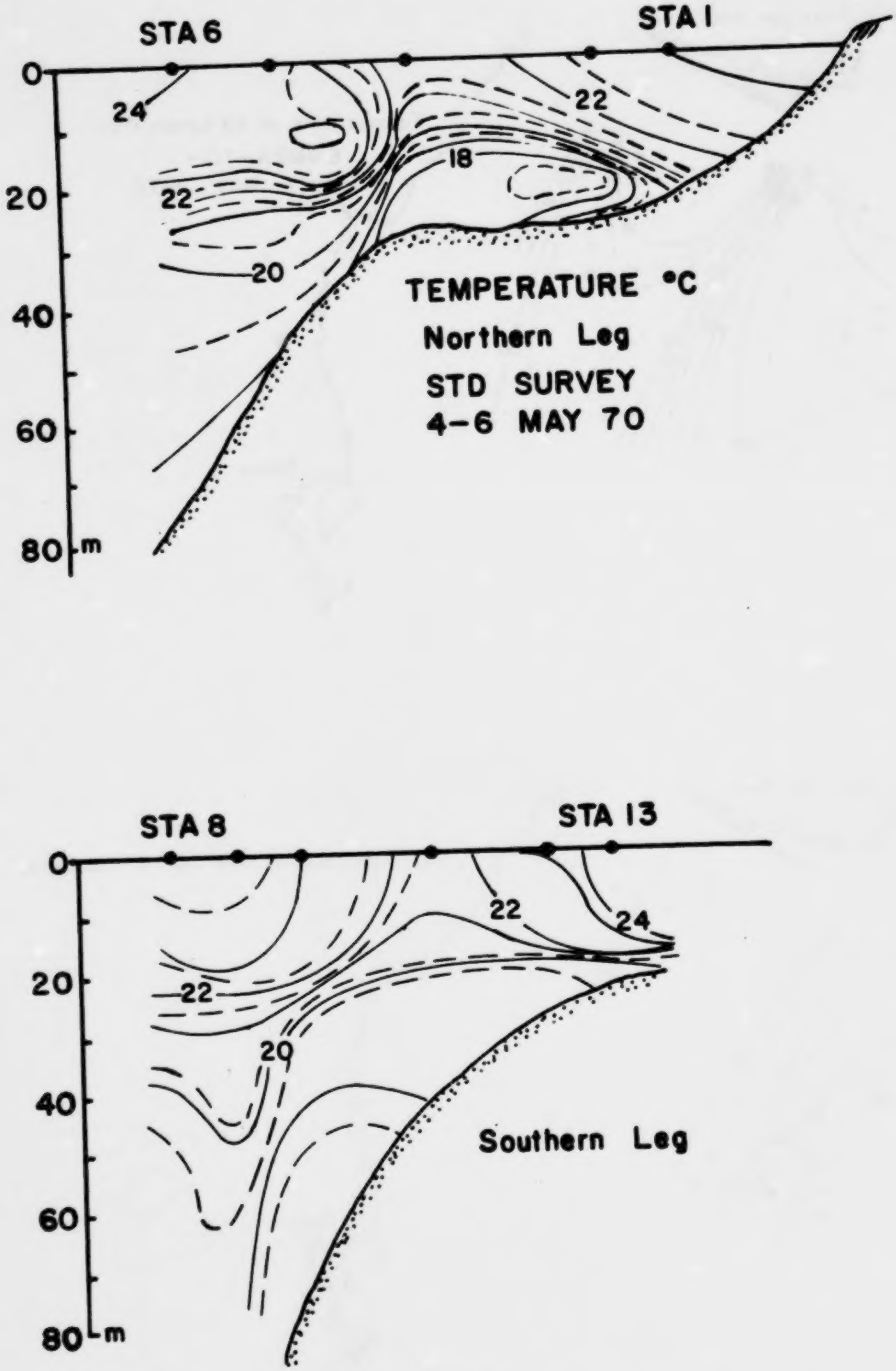
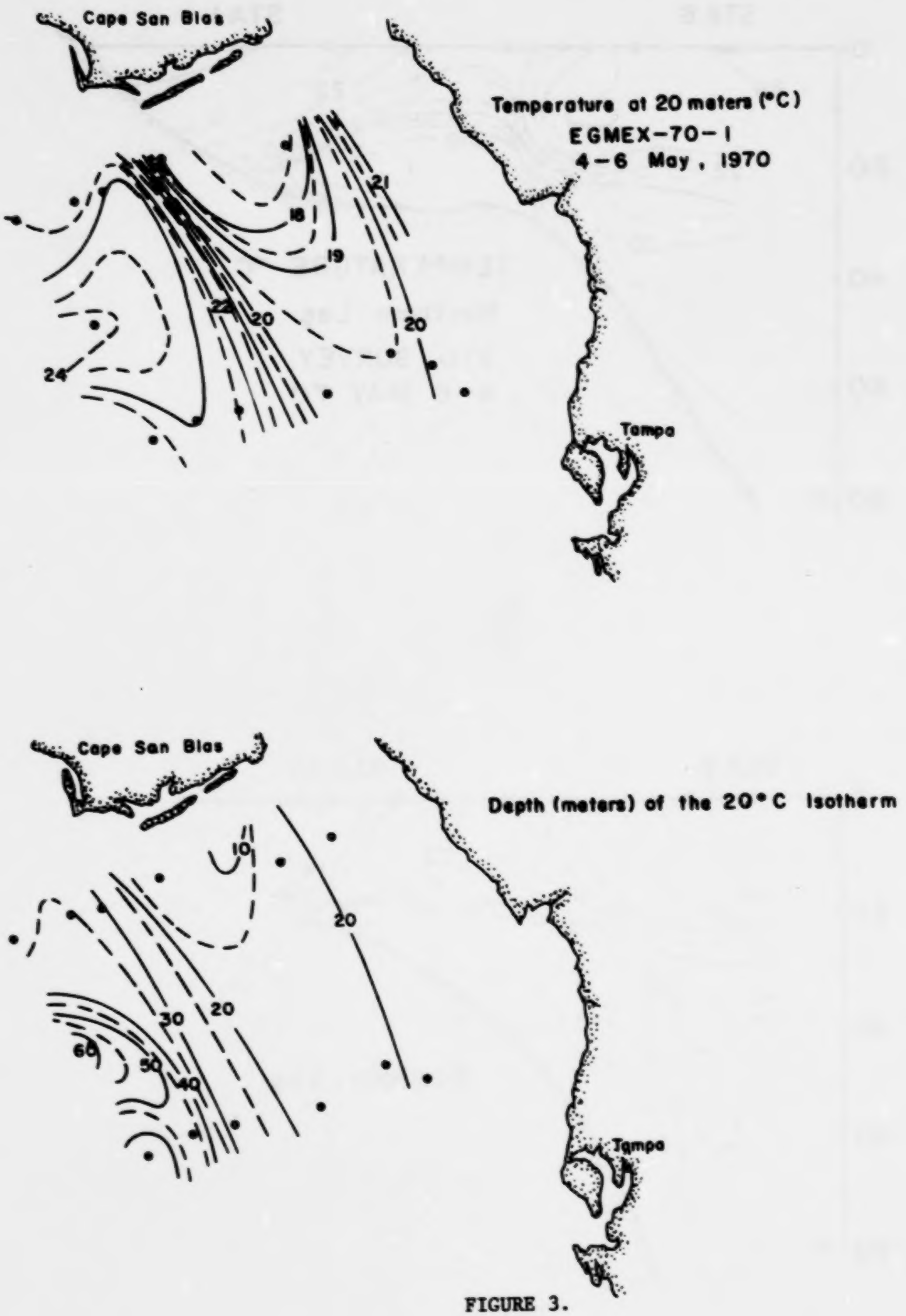

STA 6
STA 1
0
20
40
60
80 m
24
22
18
22
20
TEMPERATURE °C
Northern Leg
STD SURVEY
4-6 MAY 70
STA 8
STA 13
0
20
40
60
80 m
22
24
22
20
Southern Leg

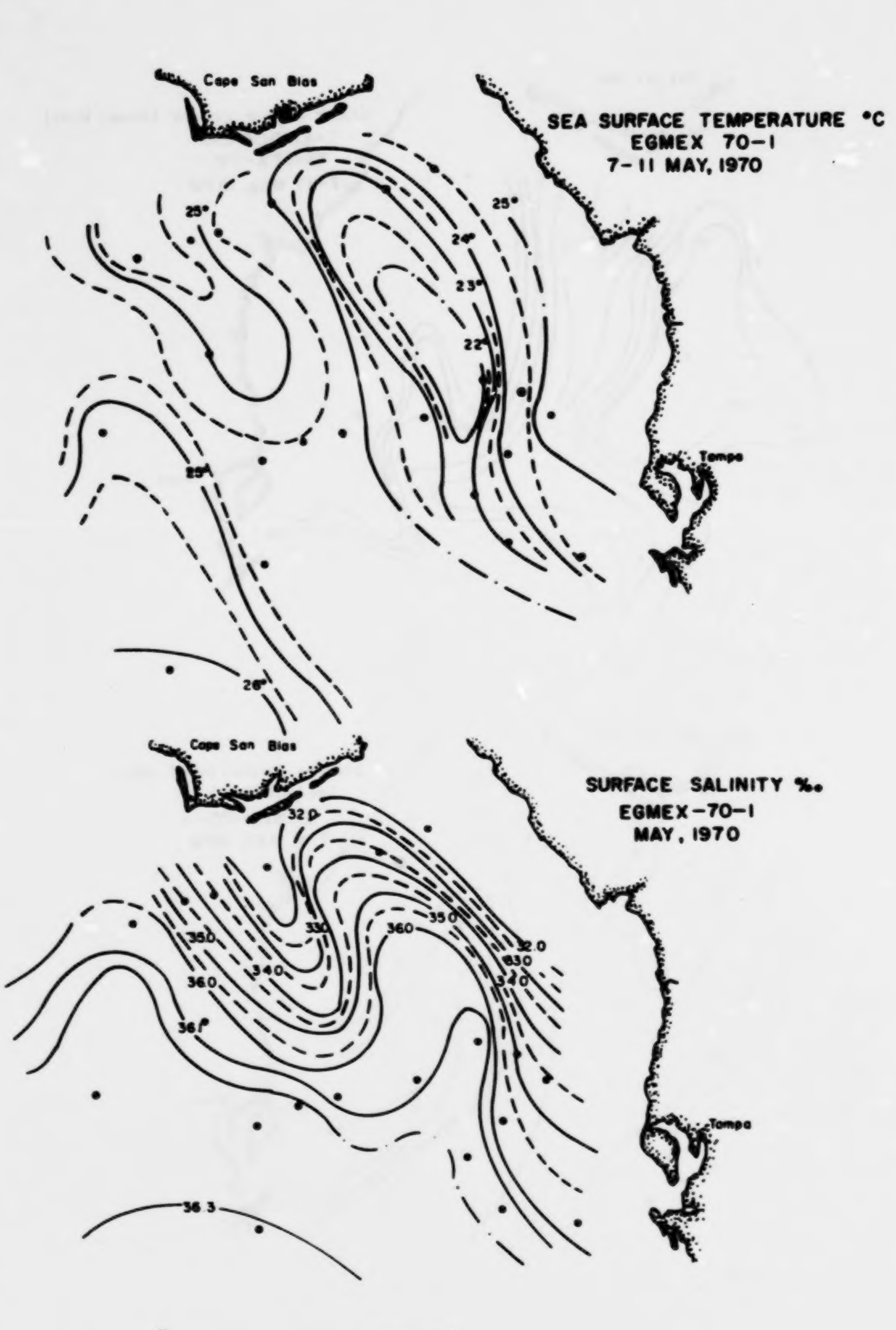
FIGURE 2.


Temperature at 20 meters (°C)
EGMEX-70-1
4-6 May, 1970

Depth (meters) of the 20°C Isotherm

Cape San Blas
21
18
19
22
20
20
24
Tampa
Cape San Blas
10
20
30
20
60
50
40
Tampa

FIGURE 3.


SEA SURFACE TEMPERATURE °C
EGMEX 70-1
7-11 MAY, 1970

SURFACE SALINITY ‰
EGMEX-70-1
MAY, 1970

Cape San Blas
25°
25°
24°
23°
22°
Tampa
25°
26°
Cape San Blas
32.0
33.0
35.0
36.0
35.0
34.0
36.0
36.1
32.0
33.0
34.0
Tampa
36.3

FIGURE 4.

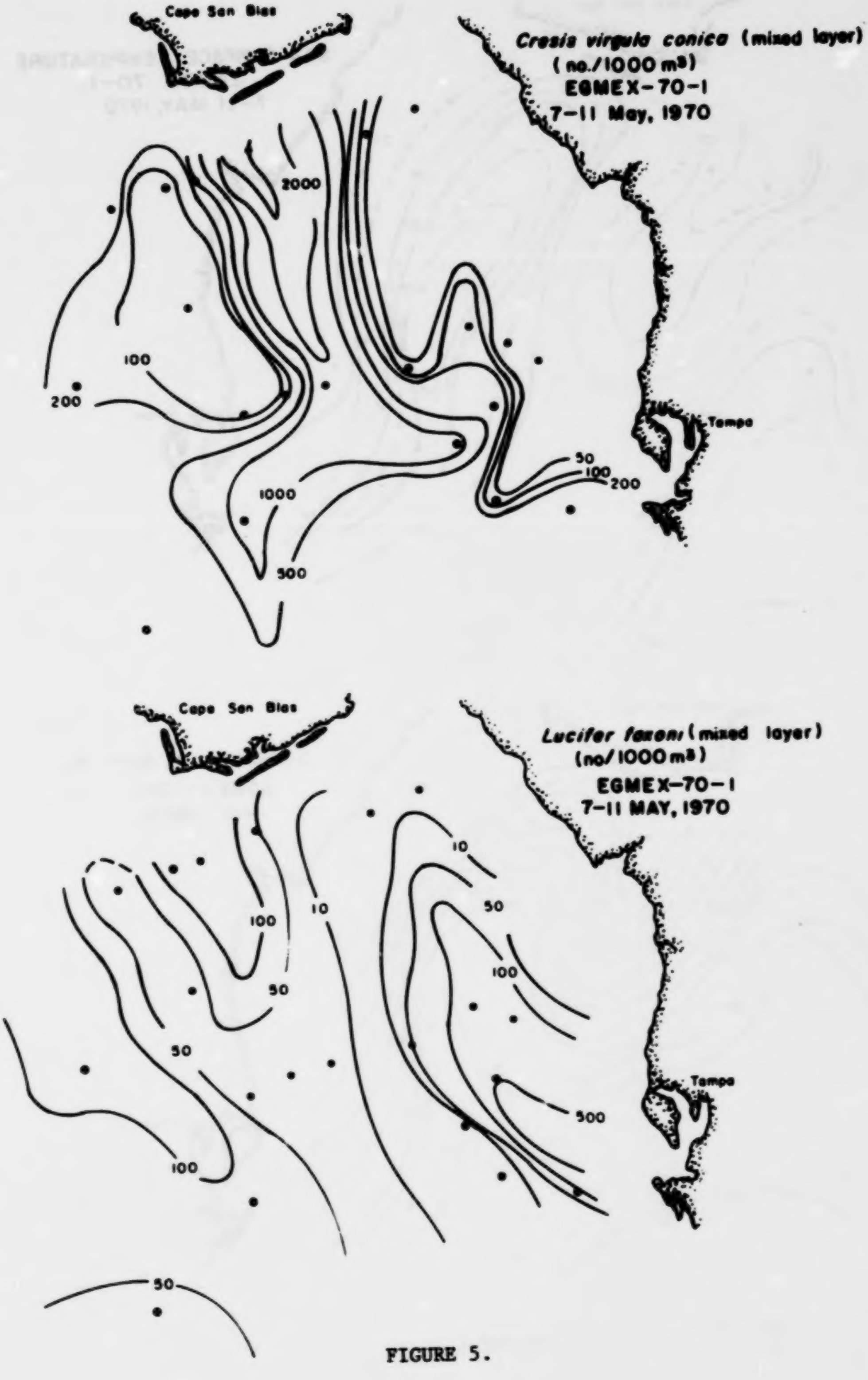
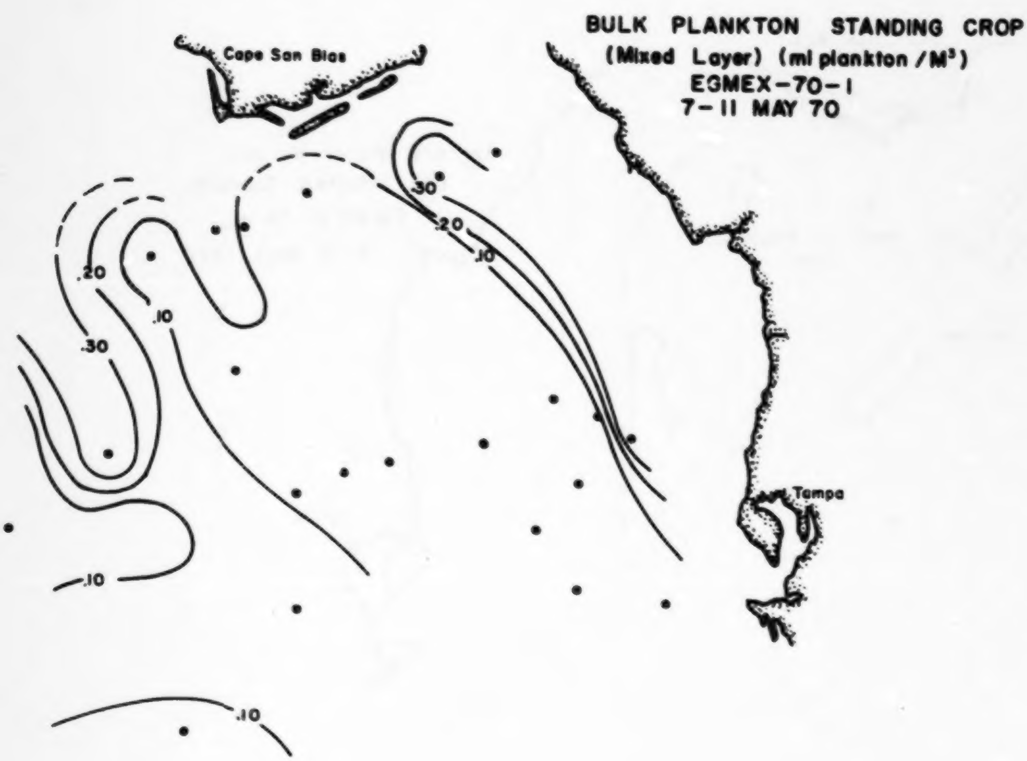

Cape San Blas
Cresis virgula conica (mixed layer)
(no./1000 m³)
EGMEX-70-1
7-11 May, 1970
2000
100
200
1000
500
50
100
200
Tampa
Cape San Blas
Lucifer faxoni (mixed layer)
(no/1000 m³)
EGMEX-70-1
7-11 MAY, 1970
10
100
10
50
50
100
50
100
500
Tampa
50

FIGURE 5.


BULK PLANKTON STANDING CROP
(Mixed Layer) (ml plankton / M³)
EGMEX-70-1
7-11 MAY 70
Cape San Blas
Tampa
.30
.20
.10
.20
.10
.30
.10
.10

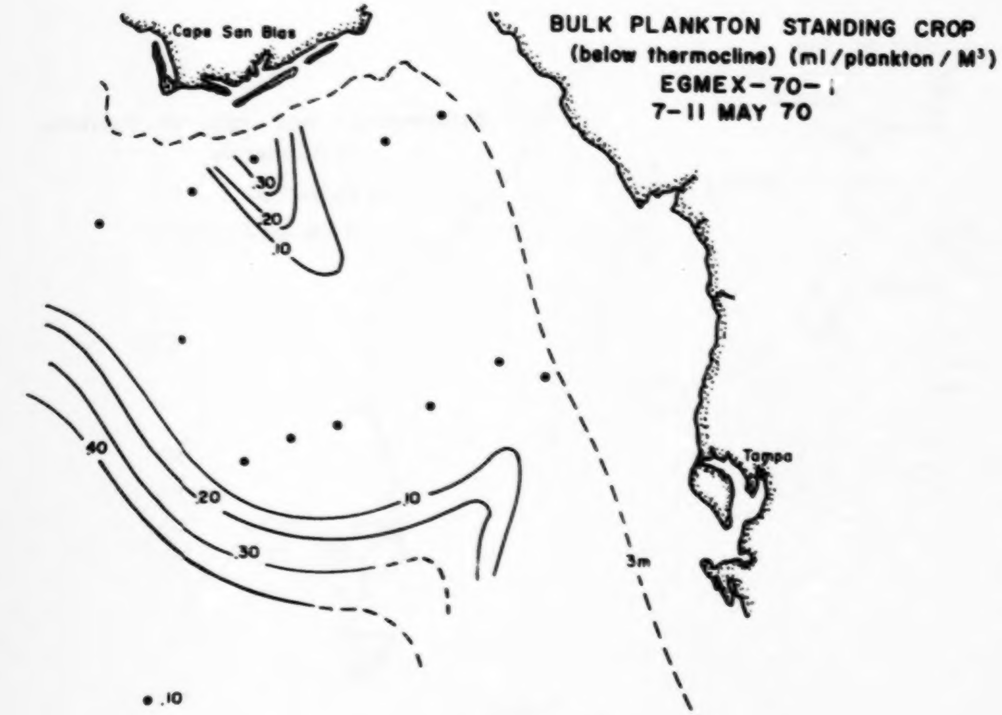
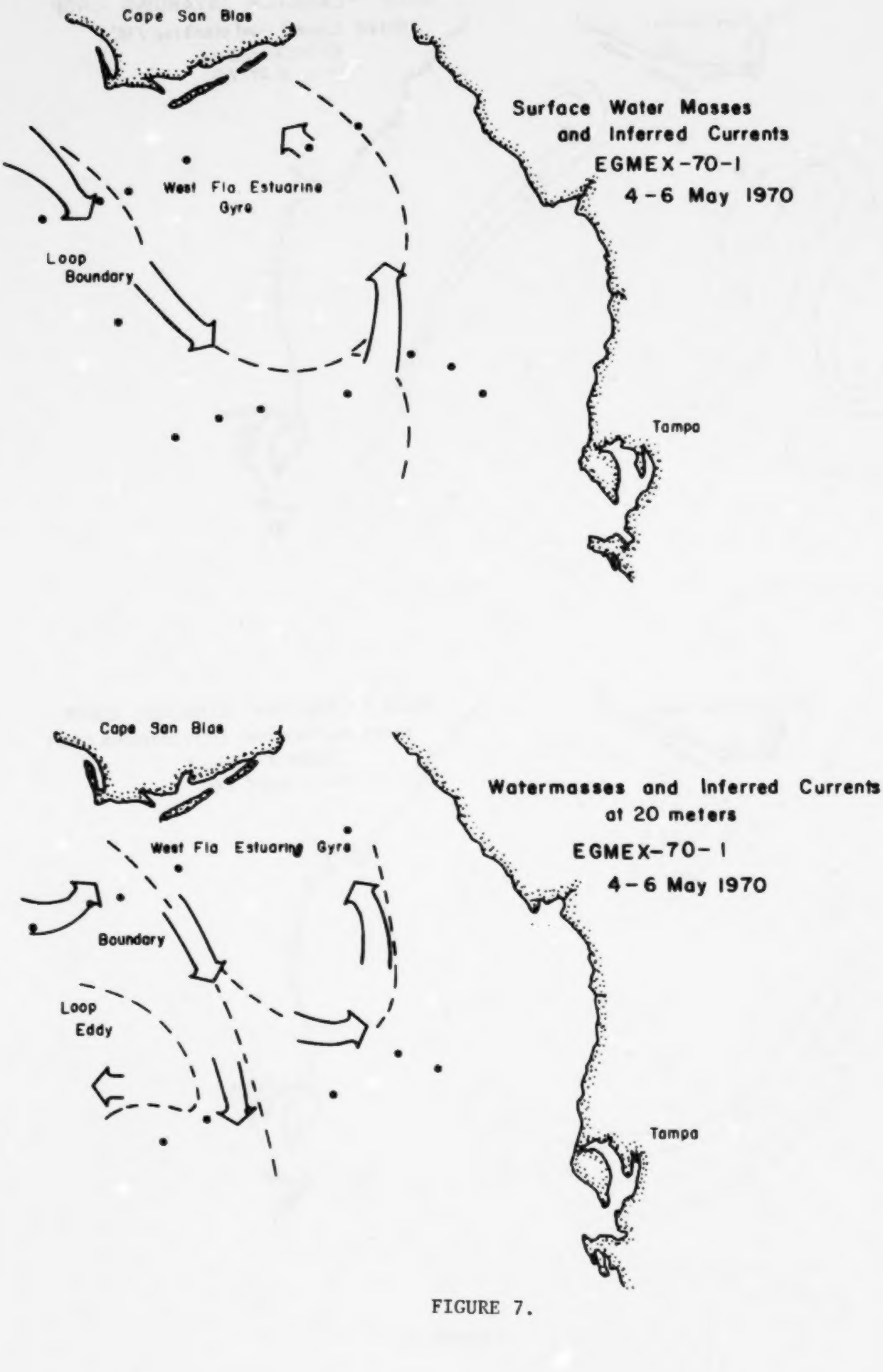

BULK PLANKTON STANDING CROP
(below thermocline) (ml/plankton / M³)
EGMEX-70-1
7-11 MAY 70
Cape San Blas
Tampa
.30
.20
.10
.40
.20
.10
.30
3m
.10

FIGURE 6.



Surface Water Masses and Inferred Currents EGMEX-70-1 4-6 May 1970

Watermasses and Inferred Currents at 20 meters EGMEX-70-1 4-6 May 1970

Cape San Blas
West Fla Estuarine Gyre
Loop Boundary
Tampa
Cape San Blas
West Fla Estuarine Gyre
Boundary
Loop Eddy
Tampa

FIGURE 7.

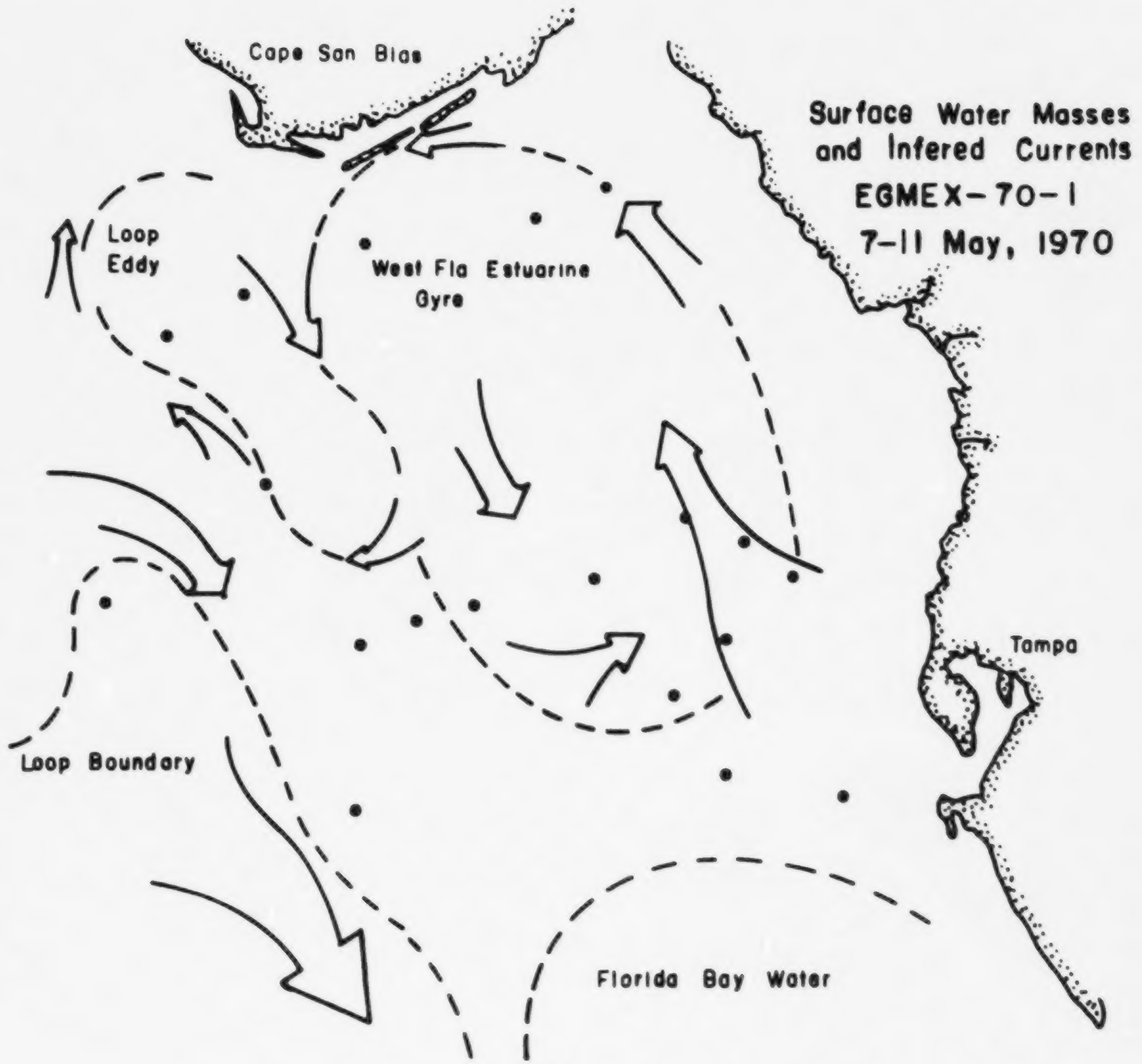

Surface Water Masses
and Infered Currents
EGMEX-70-1
7-11 May, 1970
Cape San Blas
Loop
Eddy
West Fla Estuarine
Gyre
Tampa
Loop Boundary
Florida Bay Water

FIGURE 8.

Comments on Proposed Environmental Studies of the Impact of OCS Oil Drilling in the Gulf of Mexico

Frederick Bell*
Florida State University
Tallahassee, Florida

Philip E. Sorensen*
Florida State University
Tallahassee, Florida

It appears that the U.S. Bureau of Land Management has committed itself to funding a group of physical and biological studies of the impact of offshore oil production in the Gulf of Mexico which will be conducted concurrently with exploratory drilling and well development by private industry but prior to actual production. This commitment follows meetings between Governor Askew and Senator Chiles of Florida and Secretary Rogers Morton of the U.S. Department of Interior on December 3, 1973. In a letter to Governor Askew, Secretary Morton stated, "As currently conceived, the studies will include a two-year baseline study to collect additional information on the basic biological, chemical, geological and physical characteristics of the affected offshore areas and a monitoring study which will be undertaken over a number of years to determine how these basic characteristics are affected by offshore drilling and production." The recent St. Petersburg conference implicitly accepted the notion that only physical and biological studies of the marine environment would be conducted in the first years of the BLM program by including no social scientists on the program and, in effect, attempting to determine only which kinds of physical and biological studies ought to be funded.

Without intending a blanket indictment of the research program presently contemplated by BLM, we feel compelled to make known our fears that a significant part of the research funded under the present plan will turn out to be either internally or externally inconsistent with the ultimate goal of evaluating social and economic trade-offs of oil drilling in the Gulf. As the writers of the Final Environmental Statement for the MAFLA sale concluded, "A central feature of many of these studies is that they are never really completed in the sense that they rarely reach definite conclusions with wide applicability, but simply advance from one stage to another, from one level of analysis to another, thereby contributing to a growing area of knowledge and body of literature pertaining to the numerous complexities of environmental analysis." (Vol. 3, p. 347.)

An example of the difficulty of using isolated biological data to evaluate the social cost of oil production is given by several environmental studies of the Santa Barbara Oil Spill which indicated that large

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numbers of barnacles, limpets, and sea grasses had been killed by the spilled oil. The economic or social significance of these events was impossible to know, however, because the researchers had not been asked to connect their studies to other biological or environmental systems directly impacting upon man's use of the coastal zone. Thus, these impacts had to be evaluated on an absolute basis, involving inevitable conflicts in values and philosophies. Will not the forthcoming Gulf oil studies, as presently planned, also reach the same kinds of conclusions, leaving us little better able to decide whether oil production ought to be pushed forward?

We believe an important analogy to the present situation is to be found in the Climatic Impact Assessment Program (CIAP) of a proposed high-altitude aircraft fleet (projected to 1990) conducted by the U.S. Department of Transportation (DOT). The parallels and lessons we can learn are striking! DOT brought in fifty-six contractors for a variety of physical scientific studies such as the impact of engine emissions on the stratosphere and the biological effects of tropospheric changes, following an initial plan that CIAP be confined to "good science and engineering." Later, DOT admitted that the physical science studies were but one part of the equation for transmitting scientific knowledge into social decision making. Therefore, they added a final study on "The Social and Cost Measurements of Biological Change." Unfortunately, much of the scientific data were not in a form readily translatable into economic costs or external effects of the use of the atmosphere on surface industries. The CIAP "shot-gun approach" to physical science studies lacked an overall social decision-making framework. After considerable waste and restructuring, CIAP completed the final study on the social costs to surface-based industries associated with projected aircraft travel. This final socio-economic study was in terms of dollars and cents or jobs lost and gained. It thus provided a basis for legislators and ultimately the people to evaluate the relevant social and economic trade-offs.

In the present case, we believe that two economic studies are really needed:

1. An economic framework study to fix methods by which social and economic trade-offs can be identified. This would involve exact specification of the necessary physical-biological science studies and data necessary as inputs.

2. A final economic study to compute social losses or gains associated with oil drilling.

As a guide to this approach, it should be noted that the Delaware Bay Oil Transport Committee recently completed a study entitled, Energy, Oil and the State of Delaware. This would be an excellent model for the Gulf of Mexico oil drilling study since its ultimate objective was an "Economic Evaluation of Selected Terminal Proposals and Alternative Proposals" (Chapter 8). The social objectives were spelled out in advance so that the physical science studies were consistent and usable when the final problem of social and economic trade-offs was dealt with.

In simple terms, we believe no program of environmental studies of the Gulf should be embarked upon without a significant social science component both as a guide to the forms and interconnections between the biological and physical data to be accumulated and as a link to the policy questions which must eventually be answered about the net social benefits of the proposed oil production.

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*Frederick Bell
Professor of Economics and
Sea Grant Program Coordinator
Florida State University

*Philip E. Sorensen
Associate Professor of Economics
and Chairman,
Energy Action Group,
Florida State University

The Need for Studies of Marine Mammals in the Eastern Gulf of Mexico (1974)

David K. Caldwell and Melba C. Caldwell
Biocommunication and Marine Mammal Research Facility
University of Florida
St. Augustine, Florida

Abstract

In any survey of a marine environment the mammals must be considered--especially in light of recent regulations pertaining to them. While in general the marine mammals of the eastern Gulf are not endangered by man's current or immediately-projected activities, there are certain species (especially the Atlantic bottlenosed dolphin, the Atlantic spotted dolphin, the manatee and the introduced California sea lion) that might be affected by such activities. While general data are available on the distribution of marine mammals in the eastern Gulf, more detail is needed. Also needed is information on the food habits and reproductive biology of these animals in order to predict the long-term effects that alteration of food potential and reproductive ability might have on this now highly-protected group of animals.

* * *

With the passage of the Endangered Species Conservation Act of 1969 (revised 1971), and especially of the Marine Mammal Protection Act of 1972, considerable attention has been focused on the marine mammals. Until the past decade or two, these had received little attention from science except on a very sporadic basis or as certain members related to commercial fishing. The recent legislation pertaining to all of the marine mammals is very strict, and in some instances these animals are doubly protected under both the 1969 and 1972 Acts (see Table 1). Much hard-core data are therefore needed on this group.

On the Outer Continental Shelf in the eastern Gulf of Mexico only the cetaceans (whales and dolphins) are present; there are no true porpoises in the Gulf. However, in addition to certain cetaceans, pinnipeds (seals and sea lions) and sirenians (manatees or sea cows) are found near shore in areas that would be influenced by drilling activities even offshore.

As free-swimming, air-breathing, mammals that bear their young alive and keep them with them for varying periods of time after birth (at least 6 to 12 months), cetaceans offshore are less likely to be

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directly affected by drilling activities there than most organisms. It is likely that they would merely swim out of harm's way in any very localized environmental disruption. However, they do often tend to follow rather delimited routes in their movements, and in some species at least they appear to have somewhat restricted home ranges. Inshore, the pinnipeds and sirenians (also free-swimming, air-breathing mammals that bear their young alive and nurture them for relatively long periods) appear to have even more restricted home ranges and habitat requirements although, like the cetaceans, they are capable of moving out of harm's way and would probably do so when the danger was local. Both, however, tend to be hit by fast-moving small boats.

Secondarily, all marine mammals in the region of the Gulf of Mexico, with the exception of the manatee, are carnivores. The large whales, except for the sperm whale which eats large squid and some fishes, are primarily zooplankton feeders. The smaller "whales" and dolphins feed on fish and/or various kinds of pelagic cephalopods. A few also eat some crustaceans. Pelagic fishes are chiefly involved, but in inshore waters some of the fishes living at or near the bottom are also eaten. Consequently, any man-made problem which might affect food supply would in turn affect the marine mammals that are highly protected--by human emotion, all too often, as well as by the law. Consequently, these mammals must be given special consideration as any study of potential damage to their food resources progresses. This is a generality that applies, of course, to any food chain, but because marine mammals are essentially at the top of their food chain, and because they do enjoy these special protections under the law, they must perhaps be given more consideration than might otherwise be their due.

The pinnipeds and manatees are the marine mammals most vulnerable to habitat modifications. The manatees require certain types of littoral habitats, and concurrent vegetation for food. These are both subject to modification by pollution and/or physical destruction.

Sea lions, the only pinnipeds now known to occur in the eastern Gulf, have been accidentally introduced and as yet are not known to be reproducing. Certain types of construction such as rock "islands" might encourage this. In any case, being both widely-spaced and accidental members of the eastern Gulf fauna, it is not likely that they are subject to pressures brought about by man in that region--certainly not as a native species.

We have recently outlined the status of marine mammals in the Gulf and some of the problems and needs associated with them in that region (Caldwell and Caldwell, 1972, 1973). Those reports, especially the one for 1973, also summarized literature and specific records for eastern Gulf marine mammals. While a few additional records and data have been gathered, there are no significant changes in the overall picture and we refer interested readers to those reports.

Several problems lend themselves to study under the umbrella of needs suggested by this conference. Data already are at hand to provide a beginning for such needed studies. Examples of these are:

1. A complete inventory and survey of all available data on the distribution (both geographical and seasonal) of the marine mammal fauna of the Gulf and related areas such as the Caribbean, West Indies, and southeastern coast of the United States. Wherever possible, information on food habits, ecological requirements and reproduction biology should be included along with any relationships to man.

2. The cetacean species most likely to be encountered during any work in the eastern Gulf region is the Atlantic bottlenosed dolphin (*Tursiops truncatus*). While it might be expected on the Outer Shelf, it would be found more often in inshore and estuarine waters. Here, *Tursiops* might be affected by pollution of both air and water caused by shore and near-shore activities. Likewise, as a very catholic feeder, its food might be affected or modified by habitat changes. Therefore, more should be learned of the food habits of this species, its reproductive biology and needs, and its movements both daily and seasonally, and geographically. Several types of tagging studies might be employed singly or in concert in the latter work.

3. The spotted dolphin (*Stenella plagiodon*) is probably the most common species to be expected in the eastern Gulf over the Outer Shelf. It also appears in inshore waters at certain times of the year. Although studies on this species would be more difficult to pursue than similar ones on the bottlenosed dolphin, it would be desirable to attempt them on a more limited scale.

4. There is already a considerable body of data on the manatee (*Trichechus manatus*) in this region and on the California sea lion (*Zalophus californianus*) in its native Pacific waters. Even so, additional work on them is needed relative to specific potential changes brought about by oil drilling.

The personnel and many of the facilities for these and other studies are already available through SUSIO and our facility. Basic data have already accumulated in many cases, and as is the case with so many projects today, only financial assistance is required to bring the projects to completion.

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Table 1. Marine mammals recorded or expected from the eastern Gulf of Mexico. Those marked with a dagger are known from the western Gulf and consequently should be expected on the eastern side although they are not yet reported from there. Those marked with an asterisk are considered by the U. S. Environmental Protection Agency to be "endangered".

Cetaceans	
Black right whale (*Eubalaena glacialis*)*	Near shore to high seas
Minke whale or Little piked whale (*Balaenoptera acutorostrata*)	Shelf to high seas
Sei whale (*Balaenoptera borealis*) † *	Shelf to high seas
Bryde whale (*Balaenoptera edeni*)	Shelf to high seas
Fin whale (*Balaenoptera physalus*) *	Shelf to high seas
Humpback whale (*Megaptera novaeangliae*) *	Near shore to high seas
Sperm whale (*Physeter catodon*) *	Shelf to high seas
Antillean beaked whale (*Mesoplodon europaeus*)	Outer shelf to high seas
Goose-beaked whale or Cuvier's beaked whale (*Ziphius cavirostris*)	Outer shelf to high seas
Pygmy sperm whale (*Kogia breviceps*)	Shelf to high seas
Dwarf sperm whale (*Kogia simus*)	Shelf to high seas
Rough-toothed dolphin (*Steno bredanensis*)	Shelf to high seas
Atlantic bottlenosed dolphin (*Tursiops truncatus*)	Coastal zone to inner high seas
Gray grampus or Risso's dolphin (*Grampus griseus*)	Shelf to high seas
Long-snouted dolphin (*Stenella* cf. *longirostris*)	Shelf to high seas
Atlantic spotted dolphin (*Stenella plagiodon*)	Coastal zone to high seas
Bridled dolphin (*Stenella frontalis*)	Shelf to high seas
Striped dolphin or Euphrosyne dolphin (*Stenella coeruleoalba*)	Shelf to high seas
Unidentified dolphin (*Stenella* sp.)	(?) Shelf to high seas
Common dolphin or Saddleback dolphin (*Delphinus delphis*)	Shelf to high seas
Pygmy killer whale (*Feresa attenuata*) †	Shelf to high seas
False killer whale (*Pseudorca crassidens*)	Shelf to high seas
Short-finned pilot whale or Blackfish (*Globicephala macrorhyncha*)	Shelf to high seas
Killer whale (*Orcinus orca*)	Shelf to high seas
Sirenians	
Manatee or Sea cow (*Trichechus manatus*) *	Coastal zone
Pinnipeds	
California sea lion (*Zalophus californianus*)	Coastal zone to inner shelf (Introduced)
Caribbean monk seal (*Monachus tropicalis*) *	Coastal zone (Probably extinct)

Note: The Blue whale (*Balaenoptera musculus*) has been recorded from the western Gulf, but the records have been questioned. It has not been reported from the eastern Gulf.

Scientist-in-the-Sea*

LT George C. Green, USN
Naval Coastal Systems Laboratory
Panama City, Florida

Wilbur H. Eaton
Naval Coastal Systems Laboratory
Panama City, Florida

Abstract

The Scientist-in-the-Sea Program, known by the acronym "SITS", is a 10 week graduate level course, conducted annually in Panama City, Florida, and supported by the Naval Coastal Systems Laboratory, the State University System of Florida, and the National Oceanic and Atmospheric Administration. Through this unique program, a highly-select group of graduate students in marine science, ocean engineering, or associated disciplines is exposed to and provided with a practical working knowledge of the most current underwater equipment and techniques that the Navy has to offer. This is one of the few programs in the country where the Navy's tremendous technological resources regarding the oceans and diving are being shared with the civilian community. In addition, the course curriculum is supplemented with scientific instruction and principles emphasizing the marine environment. It must be emphasized that the Scientist-in-the-Sea Program is devoted to future scientists and is not a training course for diving technicians.

To date, three Scientist-in-the-Sea Programs have been successfully conducted and 41 students have been graduated. The fourth SITS Program will start this June, with 20 students from around the country participating.

Introduction

Man has been involved in scientific studies of the ocean since he first realized its resource potential. But the preliminary efforts were limited by inadequate and crude equipment and techniques. Because there was no pressing requirement for exploitation of the seas, these early

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* A presentation to be read at the "Working Diver Symposium - 1974," and published in the Symposium Proceedings. Symposium sponsored by U.S. Navy Superintendant of Salvage (SUPSAL), Battelle Columbus Laboratories, and Marine Technology Society (MTS); to be held 5-6 March 1974, Columbus, Ohio.

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studies were accomplished almost exclusively for purely academic or military reasons. Today, we are in an era where knowledge of the oceans is not only necessary from a purely scientific and military standpoint, but is required also for social and political reasons. As the human population continues its current explosive growth, we must depend increasingly on the seas as a source of food, minerals, water, and energy. As pointed out in a recent report of the Commission on Marine Science, Engineering and Resources entitled Our Nation and the Sea, "the full realization of the potential of the sea is presently limited by lack of scientific knowledge and the requisite marine technology and engineering." These limitations include:

1. Inadequate scientific knowledge about natural coastal zone processes.

2. Inadequate understanding of our fisheries resources.

3. The need to develop and apply modern techniques to the culture of certain marine animals and plant species.

4. The need to improve the fundamental technology that will make it possible to exploit undersea minerals commercially (both exploration and recovery techniques).

5. Inadequate knowledge about the interactions between the oceans, the atmosphere, and the earth, and the need to monitor, predict, and eventually, modify natural environmental processes for beneficial ends.

6. Inadequate fundamental technology influencing the effectiveness of the man-in-the-sea operations—including man's physiological and psychological capabilities underwater, and the need for improved underwater tools, communications, life support systems, and various devices that will provide a diver with greater mastery over his underwater environment.

Thus, in order to satisfy the world's long-range marine objectives, the scientific community--both military and civilian—must devote much more time, energy, and money to extensive scientific studies and exploration of the oceans. It is imperative, therefore, that the present corps of marine scientists, engineers, and technicians be expanded. Through such programs as the Scientist-in-the-Sea, a cadre of ocean-oriented scientists and engineers is being created to meet this objective. These new researchers are made aware of the potential resources of the sea, are able to effectively implement their academic knowledge in the ocean environment, and may be expected to direct and train others to work effectively and efficiently in the sea.

It is only natural that the Naval Coastal Systems Laboratory, which is deeply involved in ocean research and development, should participate in such a program as Scientist-in-the-Sea. Approximately one-third of the Laboratory's R&D effort is in ocean technology and ocean-oriented systems. Thus, the civilian scientific community can effectively capitalize on the Laboratory's existing assets by using SITS as the vehicle for transferring the Navy's wealth of technical information concerning the oceans to them.

The SITS Program represents a cooperative effort of the Naval Coastal Systems Laboratory (NCSL) and the University System of the State of Florida. Scientists and educators from the academic community are combined with professional engineers and divers from the military community to produce a superb interdisciplinary and versatile faculty, effectively blending the latest technological developments and techniques of the U.S. Navy diving programs with the scientific research methods of the university systems. In establishing a smooth, harmonious working relationship with the academic community, the U.S. Navy's diving program is enhanced by exposure to the fresh, imaginative and innovative ideas of the participating students. In addition, many of these young students will ultimately find themselves in positions of responsibility in the marine science field and their future contributions and policies may well augment and strengthen the Navy's present and future ocean R&D programs. Thus, the Scientist-in-the-Sea Program, while contributing to the educational and informational needs of the participating students, also contributes to the future of the entire marine science community, both military and civilian.

History

The Scientist-in-the-Sea Program was conceived in the summer of 1970, as an effort to provide for a select group of graduate students in the marine sciences an intensive didactic and practical course encompassing a broad spectrum of manned undersea operations. The course was designed to provide its students with a practical working knowledge of the most current equipment and techniques utilized in underwater work, as it might apply to any field of ocean science or engineering. In order to best accomplish these aims, it was deemed necessary to enlist in equal measure the skills and equipment of the U. S. Navy and the academic expertise available in the faculties of the State University System of Florida, with further assistance from visiting lecturers of established reputations in their respective fields of undersea science and engineering.

The first 10-week course, "SITS I", was initiated in October 1970, in Panama City, Florida. Navy cooperation and support came from the Naval Coastal Systems Laboratory, with outside academic faculty drawn from teaching members of the various universities of the State of Florida. Funding for the program was grossly inadequate by any standards, but the obvious merits of the scheme, coupled with the enthusiasm of participants and the general aura of goodwill sustained the effort to a remarkably successful conclusion. Support from the Navy came through provision of advanced diving equipment, surface craft, and top-notch instructors for daily operational work. Sabbatical lecture time was made available for visiting professors, and established experts provided guest lectures, usually at their own expense. Medical care and extensive physiological monitoring came from the Navy Medical Department; and the technical libraries of the area were made available. This was the format of the first Scientist-in-the-Sea course, which—despite hasty planning and sparse funding—accomplished a significant portion of its intended goals. Ten students were graduated from the initial SITS endeavor.

Immediately after graduation of the SITS I class, the Steering Committee held a series of meetings to review, revise, and plan funding for the next course to follow. From the outset, it was apparent that, although some deficiencies existed in the training program, lack of formal funding was the critical issue to be addressed. For the pilot program, the Naval Coastal Systems Laboratory had been extremely generous in provision of professional manpower, station facilities, and advanced undersea equipment. It was readily recognized that a realistic budget must be established for at least partial funding of professional salaries and expenses, and honoraria and travel funds for distinquished lecturers. Purchases of permanent plant account equipment were a real necessity, and administrative procedures could no longer be accomplished on a "cumshaw" basis.

With these considerations in mind, the Steering Committee prepared a formal application for funding assistance from the Sea Grant Office of The National Oceanic and Atmospheric Administration (NOAA). In addition, various designated committees within the SITS organization concentrated on such important matters as curriculum revision, academic accreditation,use agreements, hardware acquisition, selection criteria, and a host of related subjects. Thus, a follow-on SITS II program was assured under joint sponsorship of Sea Grant, the Naval Coastal Systems Laboratory, and the University System of Florida. In mid-1972, the essential committee work had been completed, necessary documents formalized, curriculum revised, appointments confirmed, and selection of the students completed. The SITS II class was formally underway in the Summer of 1972.

The second program not only had an increased student body (16 students instead of 10) but an expanded and much more relevant curriculum. In addition to the basic training received in the initial Scientist-in-the-Sea Program, the students of SITS II utilized the Navy-owned "Texas Tower" structure, Stage II, located about 2 miles offshore in the Gulf of Mexico. Using this stage as an "at sea" laboratory, the students were able to experience the natural rigors and logistic difficulties of open sea investigations, with the advantage of operating from a stable platform. To make the program even more relevant to today's subsea researcher, a one week coordinated scientific investigation was conducted by the SITS staff and students in the Middle Ground, a coral reef area of the northeastern sweep of the Gulf of Mexico. The cruise offered students an opportunity to exercise their newly acquired skills and knowledge in solving realistic problems involving the ocean environment under actual at-sea conditions.

The third Scientist-in-the-Sea Program, drawing on the experience gained during the previous programs, provided again the high intensity, wide band of instruction that has become characteristic of the SITS courses. And once more the curriculum was revised, polished and expanded.

Despite a late start caused by funding uncertainties originating with the Presidential budget cuts, the student selection process went smoothly and 16 carefully screened students were admitted. SITS III was conducted in the summer of 1973. The format for the course was basically the same as the previous SITS program, with the exception that the students participated in a saturation diving mission in lieu of a Middle Ground cruise. The underwater habitat, Hydro-Lab, was made available to the SITS program for 3 weeks through the Manned Undersea Science and Technology (MUST) Office of NOAA.

Student Selection

Critical to the success of the Scientist-in-the-Sea programs is the proper selection of students to be trained in the course. Primarily, the potential student applicant must demonstrate to the selection committee that he or she will continue a professional career in the ocean sciences. In addition, the candidates' motivation receives critical examination since his attraction to undersea exploits may not be consonant with consistent ocean oriented scientific career efforts. With this in mind, the applicant must be a participant in a bona fide graduate level program related in some fundamental way to the marine sciences (defined in their broadest manner). It is also important that the prospective candidate possess adequate swimming skills and basic diving proficiency, since the SITS Program is not a "learn to dive" course.

The student selection process has been refined over the past years by drawing on the experience from the previous three SITS programs and follows a basic pattern of self selection, committee selection, extensive medical and psychological testing, and demonstration of diving proficiency.

Self-selection is an obvious feature of the program, since all advance information supplied to applicants clearly spells out the basic selection criteria. In short, all prospective enrollees are forewarned that the selection process will not be frivolous, and that the course is designed along lines more rigorous than glamorous.

During the second stage of selection, the selection committee reviews the applicant's academic record, his physical fitness inventory, his biographical data, diving credentials, a report of an FAA physical or the equivalent, and recommendations by academic advisers and other supervisors.

The third phase of student selection includes a comprehensive Navy medical examination including a general physical examination, an extensive range of blood chemistry and morphological tests, an audiogram, electrocardiogram, chest x-ray, and a very extensive pulmonary function study. These results are evaluated by two diving medical specialists and a pulmonary physiologist.

All applicants are subjected to a session of psychological testing, which involves oral interviews and extensive written psychological tests. This screening level is utilized not so much to rule out undesirable personalities as to establish a baseline for future study. In this context, the psychological and physiological studies are repeated at specified intervals throughout the training course.

Finally, the applicants are given rigorous swimmer and diver proficiency tests, followed by exposure to a hyperbaric chamber pressure equivalent to 112 feet of sea depth. Subsequently, they are tested for susceptibility to oxygen toxicity at 60 feet seawater simulated depth.

Program Description

The present SITS curriculum can be logically subdivided into three phases in which a planned shift in emphasis occurs from a learning to an application viewpoint. These three phases include: (1) Basic Underwater Training, (2) Open-Sea Operations and (3) Saturation Diving Operations.

Although all students possessed prior scuba certification, it was felt that their proficiency in scuba would necessarily have to be increased. Accordingly, during the initial portion of the first phase, the students swam day and night compass courses, endured rigorous underwater and surface distance swims, and made indoctrination dives of 60 and 110 feet. Also during this initial period, the students participated in search and recovery exercises, were instructed in scuba equipment design and proper maintenance and overhaul procedures, and learned basic seamanship and small boat handling.

During the following weeks, the students were introduced to and practiced with the wide range of underwater systems and equipment that was available to them. Supplementing this technical diving training was an emphasis on scientific and academic instruction, including discussions of research in the undersea environment and the specific application of underwater technological capabilities toward the solution of research problems.

Some of the initial technical training and lectures involved underwater photography, encompassing not only the latest in equipment and techniques, but also a thorough review of fundamentals. The basic techniques and equipment used in umbilical diving were covered. Band masks, the Navy shallow water mask, and fiberglass hardhats were all used by the students. During this phase, the students were introduced to a variety of underwater tools. Through such underwater exercises as a pipe puzzle problem and a flanged pipe assembly problem, the students were effectively made aware of a corollary to Murphy's Law, that immutable law of the Sea: any job devised on dry land will take six times longer for execution underwater. Ensuing lectures and demonstrations covered diver speech production, underwater auditory acuity, sonar echolocation, diver navigational aids and diver communication aids.

The students gained valuable experience using both hardwire communication systems and wireless communications systems. In addition to lectures covering basic navigational principles, the students were exposed to an experimental hand-held doppler navigation device. Various hand-held sonars were used in both active and passive modes. As a demonstration of what a tremendous resource the hand-held sonar can be to the marine researcher, acoustic markers (pingers) were attached to lobsters which were subsequently released and monitored by the students for behavioral characteristics.

Mobility underwater is of concern to the diving scientist, and accordingly, the students became proficient in a variety of towed and self-propelled wet submersibles. It was immediately apparent that, though the self-propelled submersibles offered many advantages, the towed vehicles were more compatible with most university subsea research tasks, principally for economic reasons. The students were exposed to a variety of towed vehicles, ranging from a simple one-man dive plane to a sophisticated, totally enclosed two-man submersible capable of being towed up to 10 knots.

As the traditional open-circuit air scuba places many limitations on the underwater investigator, the SITS participants also became familiar with other self-contained underwater breathing apparatuses including semi-closed circuit mixed-gas scuba, closed circuit scuba using pure oxygen, and closed-circuit mixed-gas scuba. Also the students received lectures concerning the understanding and skills necessary for mixed-gas, the physics and physiology of mixed-gas diving, and the safe operation of mixed-gas equipment.

The academic curriculum during the basic training phase, in addition to emphasizing how the advanced diving techniques and equipment introduced to the students could be used for support of basic and applied science operations, also stressed scientific principles relevant to the marine environment. Initial lectures were concerned with hyperbaric physiology and medicine. Subsequent lectures covered such items as diving accidents, pulmonary ventilation in hyperbaric environment, perceptual processes in diving, behavioral and emotional characteristics in stressful environments, and selection and measurement methodology for diver training programs.

Topics in ocean engineering, marine geology and physical oceanography were discussed. These included lectures concerning the physical properties of sea water, underwater sound transmission, corrosion, underwater structural design, geological surveys, and mapping. Also included were exposures to the various instrumentation used for determining salinity, temperature, dissolved oxygen, currents, and pH measurements. Marine life sciences topics discussed included marine vertebrate and invertebrate behavior, algology, in situ measurements, waste disposal and assimilation in the ocean, vertical and horizontal zonation, aquaculture in the open ocean, and marine resource mapping.

One of the primary objectives of the SITS program is to instill in the students a sense of diving safety awareness and responsibility for all phases of the diving exercise. This is accomplished by assuring that the students are intimately familiar with all diving safety regulations and all proper dive procedures. Accordingly, the students are trained in proper dive planning, dive recording, dive implementation, and dive supervision. In this way the SITS program contributes not only to the effectiveness and safety of the students' dives, but also to the effectiveness and safety of the divers whom they will later supervise.

The second phase of the SITS curriculum involved a change in operational location and presented an opportunity to apply the newly acquired skills and knowledge to the solution of realistic investigative problems. This phase of training was accomplished on Stage II, one of the Navy's research platforms located about two miles offshore in the Gulf of Mexico. This structure, situated in 60 feet of water on a sandy ocean floor, is a self-sufficient platform providing power, compressors, communications, galley, and communal berthing spaces for as many as 30 people. The move to the stage presented the students a valuable preliminary exposure to the natural rigors and logistical problems of pursuing at-sea oceanologic investigations, albeit aboard a stable platform.

A week was spent on Stage II, during which time the students conducted actual investigative research projects encompassing a wide range of topics. The projects, which were both student generated and faculty generated, included: studies of the activity cycles and behavioral characteristics of various fish and invertebrates; fouling and corrosion studies; studies involving artificial habitats - construction, design, and biological succession and recruitment; oceanographic studies encompassing current, temperature, salinity, and dissolved oxygen measurements; and geological and mapping surveys.

For six days and six nights, repetitive dives were accomplished around the clock from the Stage, with total involvement from students and staff alike. In addition to coping with the numerous problems involving the complex process of providing logistics, communications, plant and gear maintenance, and project involvement, the students were given the responsibilities of dive supervisors, time keepers, log keepers, and stand-by divers. It was a matter of real importance that all students during this time learned the lesson of the clear need for proper logistic planning, self organization, proper budgeting of time, and good dive operational sequence procedures.

The highlight of the latest SITS curriculum was the third phase--saturation diving. Saturation diving has recently emerged as a valuable tool for the marine scientist as he is able to study and make continuous observations of the underwater environment without the physical limitations imposed by repetitive daily dives from the surface and unencumbered by the many wasted hours of decompression. Thus, in order to keep the SITS program relevant to today's subsea researcher, a saturation diving experience for all the students was incorporated into the curriculum.

The Hydro-Lab underwater habitat, located in 50 feet of water off Grand Bahama Island was made available to the program through the Manned

Undersea Science and Technology (MUST) office of NOAA. The habitat is ideally suited for a program such as the Scientist-in-the-Sea, as one of the keys to the success of the SITS saturation diving experience was the simplicity in operation of Hydro-Lab and consequently the requirement for only minimal training.

The habitat is 16 feet long by 8 feet in diameter and is capable of housing 4 persons. The hull is equipped with 8 small portholes and a large 4 foot viewing port. It rests on a sand and coral bottom, immediately adjacent to an outer reef off the coast of Grand Bahama Island. Living accommodations are Spartan but comfortable, offering bunks, showerhead, dehumidifier, air conditioning, freeze-dried foods, AC and DC lighting, and radio communications. The life support system is built into an unmanned support vessel located on the surface directly overhead the habitat. The support vessel is completely self-sufficient, maintaining internal and external breathing systems, supplying fresh water and generating electrical power for the underwater laboratory.

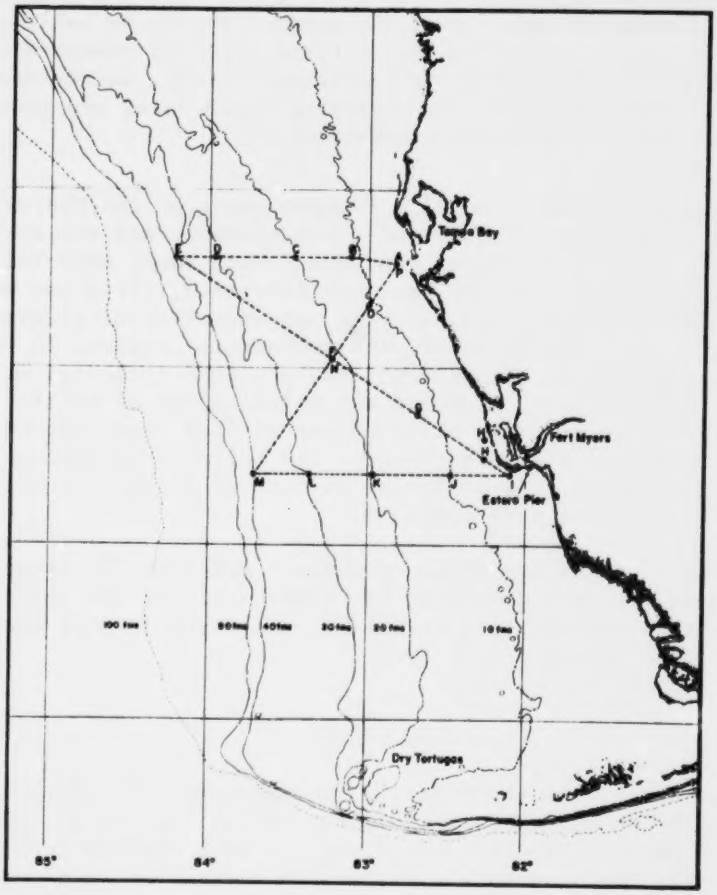
During the three weeks the SITS Program spent at the Hydro-Lab facility, six teams, each composed of three students and one staff member, participated in saturation diving missions. Each team, selected along lines of academic discipline and research interests, lived and worked from the habitat for three days carrying out experimental programs designed to make use of the knowledge and techniques acquired in the earlier phases of the curriculum. Experiments and projects included: marine microbiology; den residency of lobsters; colonization of artificial reefs; hyperbaric physiology studies; observations of fish fauna around Hydro-Lab; and the development of a grid pattern on the bottom surrounding the habitat for mapping purposes. As a finale, studies of fright reactions in fish using an artificial fish were conducted.

The Hydro-Lab missions, which terminated the SITS III Program, proved a valuable asset not only providing the final training for the students, but also for producing valuable scientific and technological yield from the experimental programs.

CONCLUSION

In conclusion, it is important to re-emphasize the uniqueness of the Scientist-in-the-Sea Program. It is not a diving technician course nor is it strictly an academic course: rather, it is a combination of the two--a technical education supplemented with a broad brush academic curriculum. It is from this diversity in training that the SITS Program derives its strength. It is also important to recognize that the relatively short duration of the program (10 weeks) dictates clearly that it be aimed at crash training rather than in-depth education.

The program is necessarily directed toward those individuals who have a high potential for and are highly motivated toward a professional career in marine-oriented sciences. The SITS Program does not create the scientist; rather it increases the tools available to the future researchers enabling each of them eventually to become an effective Scientist-in-the-Sea.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PROJECT HOURGLASS

A Systematic Ecological Study
of
West Florida Shelf Biotic Communities

Project Hourglass
A Systematic Ecological Study
of
West Florida Shelf Biotic Communities

Florida Department of Natural Resources
Marine Research Laboratory
St. Petersburg, Florida

Project Hourglass was a 28-month (August 1965--November 1967) systematic sampling program for benthic and planktonic flora and fauna collected along two east-west transects on the west Florida shelf. Five stations, in depths of 6, 18, 37, 55 and 73 m, were sampled along each transect. The transects were located off Tampa Bay and Sanibel Island, Florida, approximately 160 km apart. Additional phytoplankton stations were established at locations between the transects. Physical data (surface and bottom temperatures, salinities, etc.) taken with each biological sample have been reported by Joyce & Williams (1969. Memoirs of the Hourglass Cruises: Rationale and pertinent data. Fla. Dep. Nat. Resour. Mar. Res. Lab. Vol. 1, Pt. 1. 50 p.).

The ultimate goal of the Hourglass program is to make available basic biological information on the flora and fauna within the study area. To this end, each species is being analyzed and reported in the Memoirs of the Hourglass Cruises, a special publication series established to insure analytical continuity and single-source availability of information. Species known from the area, but not captured during Project Hourglass, are also included in analyses to insure that, when completed, the Memoirs will serve as a catalogue and basic reference to the flora and fauna of the region. Species treatments include identifications, diagnostic characters, illustrations, distributions, abundances (relative and seasonal), and such information as morphological variation, age, growth, size structure of populations, reproduction, feeding, predation, and symbiotic associations.

To date, nine papers comprising 831 pages have been published and are hereafter listed:

Camp, D. K. 1973. Stomatopod crustacea: Memoirs of the Hourglass Cruises. Fla. Dep. Nat. Resour. Mar. Res. Lab. Vol. 3, Pt. 2. 100 p.

Cobb, S. P., C. R. Futch and D. K. Camp 1973. The rock shrimp, *Sicyonia brevirostris* Stimpson, 1871 (Decapoda, Penaeidae): Memoirs of the Hourglass Cruises. Fla. Dep. Nat. Resour. Mar. Res. Lab. Vol. 3, Pt. 1. 38 p.

Cooper, G. A. 1973. Brachiopods (Recent): Memoirs of the Hourglass Cruises. Fla. Dep. Nat. Resour. Mar. Res. Lab. Vol. 3, Pt. 3. 17 p.

Dawes, C. J. and J. F. Van Breedveld 1969. Benthic marine algae: Memoirs of the Hourglass Cruises. Fla. Dep. Nat. Resour. Mar. Res. Lab. Vol. 1, Pt. 2. 47 p.

Joyce, E. A., Jr. and J. Williams 1969. Rationale and pertinent data: Memoirs of the Hourglass Cruises. Fla. Dep. Nat. Resour. Mar. Res. Lab. Vol. 1, Pt. 1. 50 p.

Lyons, W. G. 1970. Scyllarid lobsters (Crustacea, Decapoda): Memoirs of the Hourglass Cruises. Fla. Dep. Nat. Resour. Mar. Res. Lab. Vol. 1, Pt. 4. 74 p.

Saunders, R. P. and D. A. Glenn 1969. Diatoms: Memoirs of the Hourglass Cruises. Fla. Dep. Nat. Resour. Mar. Res. Lab. Vol. 1, Pt. 3. 119 p.

Steidinger, K. A. and J. Williams 1970. Dinoflagellates: Memoirs of the Hourglass Cruises. Fla. Dep. Nat. Resour. Mar. Res. Lab. Vol. 2. 251 p.

Topp, R. W. and F. H. Hoff, Jr. 1972. Flatfishes (Pleuronectiformes): Memoirs of the Hourglass Cruises. Fla. Dep. Nat. Resour. Mar. Res. Lab. Vol. 4, Pt. 2. 135 p.

In addition, reports on the following are in various stages of preparation for publication in the Memoirs:

Circulation of Surface Waters

Scleractinia (Cnidaria)

Alcyonaria (Cnidaria)

Bryozoa

Fasciolariidae (Mollusca, Gastropoda)

Turridae (Mollusca, Gastropoda)

Dentaliidae (Mollusca, Scaphopoda)

Portunidae (Crustacea, Decapoda)

Echinoidea (Echinodermata)

Pisces Checklist and Zoogeographic Analysis

Scorpaenidae (Pisces)

Synodontidae (Pisces)

Triglidae (Pisces)

Eight new species, including four gastropods, one brachiopod, one decapod crustacean, one stomatopod crustacean, and one echinoid, have been described from material wholly or primarily from Hourglass collections. All but the brachiopod were described in journals other than the *Memoirs* series:

Camp, D. K. 1971. *Platysquilla horologii* (Stomatopoda, Lysiosquillidae), a new species from the Gulf of Mexico, with an emendation of the generic definition. Proc. Biol. Soc. Wash. 84(15): 119-127.

Cobb, S. P. 1971. A new species of *Sicyonia* (Decapoda, Penaeidae) from the western Atlantic, with notes on *S. stimpsoni* Bouvier. Crustaceana 20(1): 104-112.

Lyons, W. G. 1972. A new *Fasciolaria* from the northeastern Gulf of Mexico. Nautilus 85(3): 96-100.

Lyons, W. G. 1972. New Turridae (Gastropoda: Toxoglossa) from south Florida and the eastern Gulf of Mexico. Nautilus 86(1): 3-7.

Serafy, D. K. 1970. A new species of *Clypeaster* from the Gulf and Caribbean and a key to the species in the tropical northwestern Atlantic (Echinodermata: Echinoidea). Bull. Mar. Sci. 20(3): 662-677.

Knowledge and collections obtained during the Hourglass Cruises have contributed wholly or partially to publication of 29 additional papers concerning biology of organisms of the West Florida Shelf. These include:

Birnhak, B. I., P. V. Donnelly and R. P. Saunders 1967. Studies on *Guinardia flaccida* (Castracane) Peragallo. Fla. Board Conserv. Mar. Lab., Leafl. Ser. Vol. 1, Pt. 3, No. 3. 23 p.

Collier, A., W. B. Wilson and M. Borkowski 1969. Responses of *Gymnodinium breve* Davis to natural waters of diverse origin. J. Phycol. 5: 168-172.

Davis, J. T. and K. A. Steidinger 1966. *Ceratium trichoceros* (Ehrenberg) Kofoid. Fla. Board Conserv. Mar. Lab., Leafl. Ser. Vol. 1, Pt. 1, No. 1. 3 p.

Dawes, C. J. and A. C. Mathieson 1972. A new species of *Pseudocodium* (Chlorophyta, Siphonales) from the west coast of Florida. Phycologia 11(3/4): 273-277.

Eldred, B. 1968. First record of a larval tarpon, *Megalops atlanticus* Valenciennes from the Gulf of Mexico. Fla. Board Conserv. Mar. Lab., Leafl. Ser. Vol. 4, Pt. 1, No. 7. 2 p.

Eldred, B. 1968. The larval development and taxonomy of the pigmy moray eel *Anarchias yoshiae* Kanazawa 1952. Fla. Board Conserv. Mar. Lab., Leafl. Ser. Vol. 4, Pt. 1, No. 10. 8 p.

Eldred, B. 1969. Embryology and larval development of the blackedge moray *Gymnothorax nigromarginatus* (Girard, 1859). Fla. Dep. Nat. Resour. Mar. Res. Lab., Leafl. Ser. Vol. 4, Pt. 1, No. 13. 16 p.

Futch, C. R. 1970. Larvae of *Monolene sessilicauda* Goode, 1880 (Bothidae). Fla. Dep. Nat. Resour. Mar. Res. Lab., Leafl. Ser. Vol. 4, Pt. 1, No. 21. 14 p.

Futch, C. R. and F. H. Hoff, Jr. 1971. Larval development of *Syacium papillosum* (Bothidae) with notes on adult morphology. Fla. Dep. Nat. Resour. Mar. Res. Lab., Leafl. Ser. Vol. 4, Pt. 1, No. 20. 22 p.

Glenn, D. A. 1966. *Biddulphia regia* (Schultze) Ostenfeld. Fla. Board Conserv. Mar. Lab., Leafl. Ser. Vol. 1, Pt. 2, No. 2. 3 p.

Joyce, E. A., Jr. 1968. Project Hourglass explores the continental shelf. Sea Frontiers 14(6): 352-359

Lyons, W. G. 1968. Mollusks of Project Hourglass. Am. Malacolog. Un. Ann. Rep. for 1968: 34-35.

Moe, M. A., Jr. 1966. First Gulf of Mexico record for *Lutjanus cyanopterus*. Q. J. Fla. Acad. Sci., 29(4): 285-286.

Moe, M. A., Jr. 1968. A reversed, partially ambicolorate tonguesole, *Symphurus diomedianus*, from the Gulf of Mexico. Copeia, 1968(1): 172.

Murphey, E. B., K. A. Steidinger, B. S. Roberts, J. Williams, and J. W. Jolley. In press. An explanation for the Florida east coast *Gymnodinium breve* red tide, November, 1972.

Presley, R. F. 1972. Plankton, nekton, and nightlight collections, with pertinent data, Hourglass cruises, Gulf of Mexico (1965-1967). Fla. Dep. Nat. Resour. Mar. Res. Lab., Spec. Sci. Rep. No. 32. 16 p.

Provenzano, A. J. 1968. The complete larval development of the West Indian hermit crab *Petrochirus diogenes* (L.) (Decapoda, Diogenidae) reared in the laboratory. Bull. Mar. Sci., 18(1): 143-181, 16 text-figs.

Saunders, R. P. 1967. *Chaetoceros costatum* Pavillard. Fla. Board Conserv. Mar. Lab., Leafl. Ser. Vol. 1, Pt. 2, No. 3. 4 p.

Saunders, R. P. 1968. *Cerataulina pelagica* (Cleve) Hendey. Fla. Board Conserv. Mar. Res. Lab., Leafl. Ser. Vol. 1, Pt. 2, No. 5. 11 p.

Saunders, R. P. and G. A. Fryxell 1972. Diatom distribution, p. 13-14. *In*: Chemistry, primary productivity and benthic algae of the Gulf of Mexico. Serial Atlas of the Marine Environment, Folio 22. Am. Geograph. Soc.

Steidinger, K. A. 1968. The genus *Gonyaulax* in Florida waters. 1. Morphology and thecal development in *Gonyaulax polygramma* Stein, 1883. Fla. Board Conserv. Mar. Res. Lab., Leafl. Ser. Vol. 1, Pt. 1, No. 4. 5 p.

Steidinger, K. A. 1972. Dinoflagellate distribution, p. 14-15, 23-25. *In*: Chemistry, primary productivity in benthic algae of the Gulf of Mexico. Serial Atlas of the Marine Environment, Folio 22. Am. Geograph. Soc.

Steidinger, K. A. 1973. Phytoplankton ecology: a conceptual review based on eastern Gulf of Mexico research. CRC Crit. Rev. Microbiol. 3(1): 49-68.

Steidinger, K. A. and J. T. Davis 1967. The genus *Pyrophacus*, with a description of a new form. Fla. Board Conserv. Mar. Lab., Leafl. Ser. Vol. 1, Pt. 1, No. 3. 8 p.

Steidinger, K. A., J. T. Davis and J. Williams 1967. A key to the marine dinoflagellate genera of the west coast of Florida. Fla. Board Conserv. Mar. Lab., Tech. Ser. No. 52. 45 p.

Wahlquist, C. L. 1966. *Rhizosolenia setigera* Brightwell. Fla. Board Conserv. Mar. Lab., Leafl. Ser. Vol. 1, Pt. 2, No. 1. 4 p.

Williams, J. and R. M. Ingle 1972. Ecological notes on *Gonyaulax monilata* (Dinophyceae) blooms along the west coast of Florida. Fla. Dep. Nat. Resour. Mar. Res. Lab., Leafl. Ser. Vol. 1, Pt. 1, No. 5. 12 p.

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Wollam, M. B. 1970. Description and distribution of larvae and early juveniles of king mackerel, *Scomberomorus cavalla* (Cuvier), and Spanish mackerel, *Scomberomorus maculatus* (Mitchill) (Pisces: Scombridae), in the western north Atlantic. Fla. Dep. Nat. Resour. Mar. Res. Lab., Tech. Ser. No. 61. 35 p.

In summary, 43 scientific contributions have already been published as a result of the Hourglass Cruises. When completed, the *Memoirs* alone will contain an additional 75 to 80 reports, depending upon subdivision of unworked material. Attempts to estimate the number of ancillary papers which will result from these basic studies are not presently possible.

Let's Publish

Edwin A. Joyce, Jr.
Florida Department of Natural Resources
Bureau of Marine Sciences & Technology
Tallahassee, Florida

Failure to analyze collected data in depth and publish the results represents probably the greatest waste of research monies in the United States today. All too frequently a grant-receiving research organization becomes so embroiled in its efforts to replace an expiring grant with a new one that the previously gathered data and results are never fully analysed and made available to the scientific community through publication. Furthering this problem is a general tendency for research organizations to budget inadequate time or staff for data analysis and writing, and even the best-intentioned institutions are often beset by unavoidable delays. All these factors contribute to what has come to be known as "file cabinet research": Good baseline data which will probably never come closer to publication than the hastily prepared final report resting in the files.

In addition to this file cabinet research, there are also extensive, long-term, sampling projects which will require many years to obtain the complete results at present staff and funding levels.

With the advent of exploratory oil drilling and probably oil production in the Eastern Gulf of Mexico, the concurrent requirement by EPA for environmental studies, and the apparent availability of funding for same, we in the various research areas are being offered a unique opportunity to finally bring to light much of the file cabinet research. By using funds and staff to publish the data pertinent to EPA questions, we will be better meeting our own responsibilities, providing baseline data at relatively small expense, and accomplishing this within the quickest possible time frame.

Funding should also be used to speed up the analyses of existing long-term projects such as Hourglass, EGMEX and several others pertinent to the Eastern Gulf. This is not to say that we don't need additional (on site) samples; of course we do, but if we in our planning do not seize this opportunity then we will have been derelict in our responsibilities.

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A Brief in Support of Quantitative Studies of the Substrate and Benthic Organism Communities as a Baseline for Evaluating Effects of Oil Production on the Marine Environment

Henry Kritzler
Department of Oceanography
The Florida State University
Tallahassee, Florida

The Brief

1. The case for emphasis on the substrate.

Whereas the effects of short term, disastrous phenomena such as blow-outs, spills, fires, shipwrecks and collisions, sabotage, etc. are most likely to be observed on the surface of the water column, on the beaches and shores, on marsh and mangrove vegetation and on man-made structures, the properties of the sea bottom and the composition of the biotic communities inhabiting it will furnish a better basis for evaluating long-term consequences of petroleum production to the marine environment.

The properties of the water column and the make-up of its biota may be expected to change from minute to minute at any one place because of the effects of general circulation patterns, the tides, and mixing processes, to say nothing of turbulence created by the passage, in shallow waters, of large vessels. On the other hand the bottom is the repository for the inexorable accumulation of fall-out from the water column and it is inhabited by a great diversity of plant and animal organisms that are, to all intents and purposes, fixed on its surface or buried within it. Simple fall-out of particulates -- precipitates, the sediment load of rivers and long shore currents, and organic detritus -- is compounded by absorption and chelation of solutes by silts, clays and organic materials. Benthic plants sequester organic and inorganic dissolved substances, some of this accumulating by transfer through various trophic levels in the bottom community and some being returned to the water column. Filter feeding benthic animals add to the removal of solids from the water column. The behavioral and physiological demands of benthic plants and animals leads to the establishment of peculiar concentrations of substances and particulates. The relatively ephemeral nature of the water column with its more rapid exchanges and mixing processes makes much less likely the detection of long lasting effects such as may be expected to accumulate in the sediments. Just as one looks at the ground - the soil and the rocks - rather than into the atmosphere for evidence of long-term changes in the terrestrial environment, one should look to the sea bottom for lasting effects, if any, of

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large scale activities such as offshore oil production.

2. The importance of dominant taxonomic categories

In almost all bottom biotopes which may be found in the offshore lease areas, along the routes of proposed pipe-lines, in the inlets, channels, harbors, etc. slated for modification for port facilities and terminals, the benthic communities will be found to be dominated numerically and in biomass by the polychaetous annelids, the molluscs and the crustaceans. This has been found to be the case by Blegvad (1928) and Thorson (1950) in Danish waters, and by the latter (1933, 1934, 1936) in Greenland. Sanders (1956, 1958) has shown this to be the case in Long Island Sound and in Buzzards Bay, as has Lie (1968) in Puget Sound, Hughes, et al. (1972) in Puget Sound, and by O'Connor (1972) in Moriches Bay, New York. Over the course of many years, the writer has found this to be the case in Alligator Harbor, St. Georges Sound, St. Josephs Bay, St. Andrews Bay, in the near shore off Mexico Beach, at a series of stations between Cape San Blas, Florida, and the 100 fathom line, (all in the eastern Gulf of Mexico),and in Timbalier Bay, Louisiana. It is therefore proposed that baseline studies in the Program must include attention to these taxonomic categories.

3. The necessity for covering all possible taxonomic groups

Even though the distribution of these dominant taxonomic groups has been shown to be correlated with the properties of sediments (Sanders, loc. cit.; O'Connor, loc. cit.) and assemblages of polychaete species have been shown to be indicators of sewage and industrial pollution (Reish, 1955 a and b, 1959) there remains the real possibility that indicators of long term environmental stress may be found in numerically insignificant taxonomic groups. Significance in the ecosystem is not exclusively a function of numbers. Accordingly, the collaboration of persons competent to deal with all possible taxonomic categories should be sought in the inventory of bottom communities in the Outer Shelf Program.

4. The case for emphasis on the polychaetous annelids

The polychaetous annelids have insinuated themselves into every conceivable macro- and micro- habitat in those portions of the sea ranging from transistion between fresh and brackish waters in the estuaries to well down the continental slope. They may be found in great numbers in sediments where few other forms of macrobenthos survive. They form a constituent of the community which inhabits the pore spaces in beaches. Their distributions have been demonstrated to be correlated with those of sediment types (Rhoads and Young, 1970; O'Connor, loc. cit.). As noted above they may be used as indicators of certain types of pollution. Some have become adapted to permanent residence in the water column, while other, benthic species periodically swarm into it in prodigious numbers for reproductive purposes. They play an important role in the marine ecosystem, vying with bivalve molluscs, amphipods, ostracods and benthic copepods for the recycling of organic matter by filter and deposit feeding. Blegvad and Thorson (loc. cit.) have shown that they play a very important role in the conversion of particulate detritus into nourishing food (up to 19% dry weight organic matter) for crabs, shrimp, and fin fish.

During the past twenty months, the writer has been taking quantitative samples of the benthos of Timbalier Bay, Louisiana on a quarterly basis in areas which have been under oil and gas production for thirty-five years and in control areas. While it is too soon to draw any conclusions concerning environmental impact of oil production, it may be pointed out that the polychaetes are far and away the most abundant species in the benthos. This is to be expected since this group has almost always been found to dominate the benthos in silts and clays such as those which make up the Mississippi River delta. More than eighty species have been found thus far, with as many as eighteen or twenty in a single, standard $M^2/16$ sampling unit. The record for one sampling unit, so far, is 590 individuals of one species. And the samples have not yet been completely worked up. No other major benthic animal category has so far been characterized by this level of diversity or abundance. It follows that serious attention should be given to the inventory of polychaete species, their associations and their biomass in all places likely to be directly affected by oil production and on a seasonal basis.

5. The importance of a coordinated, cooperative sampling program

In order to produce a body of data which will yield the best possible baseline concerning the benthos it is essential that all sampling be performed at the same level of quantitation. This can be accomplished by developing a consensus concerning spatial and temporal sampling patterns and how the actual sampling is to be performed --- and sticking to it. It will not be accomplished by one investigator using one type of sampling gear at his sequence of stations and on his schedule while others use different gear at different times and places. It can best be accomplished by charging and funding the person or persons best equipped to do it, to do all the collecting with the view of distributing materials and raw data to the project directors with special competences to deal with them.

For example, in connection with the Offshore Ecology Investigation, Kritzler, Hiskey and Thomas, 1974, have developed a system which yields quantitative samples of as many, uniform $M^2/16$ sampling units excised to a depth of ten centimeters as may be dictated by the numbers and dispersion of the species populations being sampled. This apparatus has been deployed with great success at depths of up to five meters and is expected to do as well in its present version at as much as 10 meters.

A version which will be effective at any depth at which divers can work for practical lengths of time, is under development. The existing version delivers, in good condition, already sieved and into the boat, everything contained in a plug of substrate 1/16 square meter in cross sectional area and 10 centimeters deep. And it can be made to deliver as many of these at each station as are desired. The dimensions of the sampling unit can be altered to suit the dictates of the sampling program.

Such a system can eliminate the confusion and ultimate accumulation of statistically incompatible packets of raw data which emanate from collaborative (but not cooperative) programs where everybody gallops off in different directions using different sampling gear at different stations and at different times. The material yielded by deployment of such a system, if passed through a rough-sorting clearinghouse manned by the requisite number of competent technicians supervised by a qualified scientist motivated more by allegiance to the objectives of the overall program than by personal ambition, will give each participant those portions of the sample with which he is competent to deal, at the same level of quantitation. Such samples will yield bodies of data to which any sort of statistical analysis can be applied, multivariate or otherwise, with everyone sharing in the proceeds. Motile epibenthos can be similarly quantitatively sampled by the diver-monitored dredge described by Kritzler and Eidemiller (1972).

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Organizational Recommendation:
SUSIO as Logistic Center

Frank T. Manheim
Department of Marine Science
University of South Florida
St. Petersburg, Florida

The MAFLA baseline studies will require a logistic center capable of coordinating the shipboard efforts of a number of investigators and research task forces. For the below reasons I suggest that the State University System of Florida Institute of Oceanography (SUSIO) may be ideally suited to serve this function and should be considered for this purpose by the Interagency Management Committee.

1. SUSIO is mandated by the Florida Board of Regents to facilitate cooperation among, and assist in, coordinating the activities of state-supported marine organizations in Florida. It is encouraged to include in such cooperation private and out-of-state organizations (including federal), where appropriate and desired. It has shown its capacity to manage multi-institutional and multi-ship efforts, notably in the EGMEX program.

2. It is situated at the best deepwater harbor facilities in the Eastern Gulf region, and is also located adjacent to both airport and Coast Guard terminals.

3. SUSIO has immediately available for cooperation the Department of Marine Science, University of South Florida, and The Marine Research Laboratory of the Florida Department of Natural Resources.

4. SUSIO is not a competing organization in respect to funded research, and hence is free to devote itself to serving all participants, however they may be chosen. It will also require minimal overhead funds otherwise drawn by research organizations, thereby increasing the proportion of funds available to support the actual research.

If an arrangement with SUSIO is concluded for the purposes of the MAFLA area studies it is, however, recommended that the added support in the form of resources for additional service facilities and personnel be adequate so that SUSIO's normal functioning in aid of non-MAFLA marine activities around Florida not be prejudiced.

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NAVAL COASTAL SYSTEMS LABORATORY

PANAMA CITY, FLORIDA 32401

PROPOSAL TO INTERACT IN THE DETERMINATION OF THE ENVIRONMENTAL IMPACT OF OFFSHORE OIL DRILLING IN THE NORTHEASTERN GULF OF MEXICO

1 FEB 1974

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1. INTRODUCTION.

The Naval Coastal Systems Laboratory (NCSL) is the Navy's principal research, development, test and evaluation center for the application of science and technology associated with military operations carried out primarily in the coastal zone. In carrying out its assigned mission, NCSL maintains in-house research and development capability for the following Navy and Marine Corps systems, subsystems and technologies:

COASTAL TECHNOLOGY

Coastal geodesy.
Shallow water oceanography.
Deployable short-range navigation systems.
Environmental monitoring/prediction.

NAVAL DIVING AND SALVAGE SUPPORT

Man in the Sea.
Swimmer delivery vehicles.
Life support systems.
Underwater communications.
Specialized tools for the diver.
Navigation systems.
Human performance studies.
Large object salvage.

INSHORE WARFARE

Coastal and river surveillance and interdiction.
Harbor and riverine defense.
Swimmer defense.
Counterinsurgency systems.
Bridge defense.
Barrier sensor systems.

ACOUSTIC COUNTERMEASURES

Surface and subsurface torpedo countermeasures systems.
Advanced simulation techniques for environment, equipments, and systems operation in shallow seas.
Underwater acoustics.
Signal processing.
Sonar technology.

MINE AND ORDNANCE COUNTERMEASURES

Minehunting systems and equipment.
Minesweeping techniques and equipment.
Booby trap countermeasures.
Analysis of foreign ordnance.
Doctrine and tactical procedures.
NATO participation.

AMPHIBIOUS OPERATIONS SUPPORT

Environmental data for operations.
Planning defense of landing area against sneak enemy attack.
Navigation, command, and control assistance.
Analyses of problem areas.

Occupying 650 acres near Panama City, Florida, the Laboratory is situated in a relatively secluded site, easily accessible to the Gulf of Mexico (Figure 1). The Bay of St. Andrew, the Gulf of Mexico and the Apalachicola River basin serve as its principal testing grounds. A number of specialized facilities, both on land and offshore, contribute to the overall capability of the laboratory, and its effectiveness in carrying out its assigned mission.

- Ocean Simulation Facility (OSF) -- A unique hyperbaric research facility to be used to create, test, and certify manned diving and working systems for use at depth of 2250 feet.

- Two Texas tower-type offshore research platforms, both instrumented, self-sufficient island laboratories for oceanographic work, one 12 miles out, another two miles offshore.

- Simulation and Computer Center--including hybrid Countermeasures Evaluator (CME) which can simulate interactions of acoustic sources, sensors, and homing devices as they move about in a three-dimensional ocean environment.

- Seafloor Platform -- The SEALAB I habitat modified as a test platform and training base. Can be placed in the Gulf for diver support R&D.

- Magnetic Village -- Approximately 220 acres of which 40 acres have been cleared of magnetic debris and equipment. Laboratory, shops, magnetically-shielded room, test tracks.

- Apalachicola Test Site -- Near Panama City, the Apalachicola River delta offers site for development, test, and evaluation equipment systems for inshore-riverine requirements.

- Heliport Complex -- Focal point for airborne mine countermeasures program. Also can be utilized for other R&D requiring high-speed air tow capability.

- Acoustic Analog Data Analysis System, 1/3 Octave -- Used to analyze voltage analog signatures in terms of level (true rms) versus time, with frequency (1/3 octave band) as a parameter.

- Underwater Acoustic Transducer Facility--For the design, testing and calibration of electroacoustic transducers or other acoustic equipment where precise positioning and sound level monitoring is required.

- Acoustic Research Tank--Accurately measures waves, utilizing a precision hydrophone positioning carriage.

- Acoustic Simulator--Permits the Laboratory to evaluate mine reactions to sounds generated by ships and underwater noisemakers without the need for full-scale sea trials.

- Digital Magnetic Simulator--Converts digital sweep-field data, in form of punched tape, to an electrical current analog.

- Automatic Electronic Ranging Instrumentation System--A real-time, two-dimensional, operationally-proved, radio-line-of-sight, range-range, all-weather, fully-automatic, precise tracking system capable of providing positional information (X-Y) with accuracies in the order of several yards.

- Shore Optical Tracking System (SOTS)--Comprised of three observation towers and accessories for tracking ships off the beach in the Gulf.

- Environmental Simulation Lab--Provides facilities for research and test work at elevated pressures, includes a 24-inch, 1,000 psi pressure chamber; 9-inch diameter, 5,000 psi pressure chamber; 8-inch diameter, 1,000 psi pressure and gas analysis instrumentation.

- Recompression Chambers--One single lock and one double lock, for use with Navy swimmer-diver program. Qualified for oxygen tolerance tests for 30 minute oxygen at 60 feet. Also for decompression sickness treatment.

- Model Towing Basin--Located in basement of main Laboratory building, 137 feet long, 13 feet wide, 4 feet deep. Used to predict hydrodynamic characteristics with models. Has instrumented precision towing carriage.

- Calibration and Standard Facility--Equipped with accurate instrument standards certified on at least yearly basis, directly traceable to NBS.

- Pier Space--3,000 feet of docking space for vessels up to 22-foot draft.

II. FACILITIES OF PARTICULAR INTEREST TO PROPOSED PROGRAM.

Several facilities are of special interest to a study of marine environmental implications of offshore drilling. Brief descriptions of the more important assets are provided below.

A. Coastal Technology Laboratory:

The Coastal Technology Laboratory, a facility of the Coastal Technology Division of NCSL, is located on the Alligator Bayou access to St. Andrew Bay. Backed by NCSL's extensive engineering and RDT&E capabilities, laboratory employs the latest instrumentation and techniques approved for water quality testing, microbiological examination, ecological assessment, and oceanographic and hydrographic survey.

While functioning primarily to meet critical Naval needs, remote access to NCSL's Burroughs 5500 Computer Facility and in-house HP10/30 computers provide automated storage, search, and retrieval of updated environmental information and bibliographies, allowing the environmental laboratory to function as an information resource center for qualified users.

B. Stage I.

Stage I is the larger and more remote of the two offshore platforms measuring 105 by 105 feet, with living and messing accommodations for 30 persons. The platform is located about 12 miles offshore in 105 feet of water, at longitude 85 degrees 54 minutes 12 seconds West and latitude 30 degrees 00 minutes 34 seconds North (Figure 2).

The first deck is split into nine sections of 35 by 35 feet each. In the south corner, the second deck is enclosed to form an instrument room 35 by 35 feet in size. Wireways leading into this compartment provide trunks for transmission or control of power supplies in the machinery spaces below. The instrument room is also furnished with 75 linear feet of workbench space and an office.

The first deck houses a repair shop, 35 by 35 feet. Sleeping and messing facilities are also located on this deck, including a 17,000 gallon fresh water tank and equipment for freezing, cooling, and dry storage to provide a 30-day store of supplies for 30 persons. The following power systems are available:

1. A 60-kilowatt, three-phase system with frequency variable from 10 to 60 cps, at maximum potential of 450 volts. Voltage varies directly with selected frequency; a program of frequency variation may be scheduled and followed automatically.

2. A 40-watt, 28V dc isotope generator.

3. A 7-KW, 110/220 single phase, variable frequency generator.

a. Stage Environmental Instrumentation.

(1) Bottom pressure array: Pentagonal in shape, this array incorporates six pressure transducers and is capable of measuring wave directional as well as amplitude information. Due to the geometry of the pressure array (100' between center and outer transducers and 117' between individual outer transducers) wave directions for wavelengths less than 105' cannot be accurately resolved. Because the array is in 105' of water, wave amplitudes for the shorter wavelength wind waves cannot be accurately measured.

(2) A multi-array of resistant wave staffs for the determination of directional wave spectra that cannot be accurately resolved by the bottom pressure array has been installed. This system is capable of measuring directions of waves having periods greater than 2-3 seconds

and wavelengths greater than 20-40 feet. The wave direction for very short, high frequency waves cannot be measured, but the amplitude spectra will be provided for all frequencies, including the high frequencies up to 2-5 Hz.

(3) Wind speed and direction sensor: A 3-cup anemometer and wind vane system is mounted 85' above the surface of the Gulf.

(4) Data recording: Four and seven track FM recorders are utilized to record the above data inputs. A dual channel strip chart recorder is also used to record data from the surface wave recorder and to monitor data being recorded on magnetic tapes. The strip chart recorder is also used to monitor wind speed.

(5) Telemetered data acquisition system. To meet the immediate requirement of the SES-100B trials program, individual voltage-controlled oscillators and discriminators for wave height bottom pressure and wind sensors have been installed. The data is transmitted from the Stage to NCSL, recorded on magnetic tape and processed through the current data handling system.

C. Stage II.

Stage II is 60 by 84 feet, with living and messing accommodations for four persons. The structure is located about two miles offshore in 60 feet of water, at longitude 85 degrees 46 minutes 30 seconds West and latitude 30 degrees 07 minutes 12 seconds North.

The first deck of Stage II is divided into sections 30 by 30 feet, housing machinery, and living accommodations.

A part of the second deck of Stage II is enclosed to provide a repair shop 30 by 30 feet in size. Above this shop the third deck is enclosed to form an instrument room 30 by 30 feet, equipped with workbenches but no office space. As on Stage I, cable raceways are provided from the instrument room to the water and to the machinery housed on the first deck.

Power is supplied by a 60-KW, 110/220/440 vac, three-phase generator with adjustable frequency.

Environmental instrumentation at Stage II is similar to Stage I.

D. Computer Analysis.

Analog wave height, bottom pressure fluctuations and wind speed time series information magnetically recorded at Stage I, or telemetered to the NCSL receiving facility, are digitized at the NCSL computer facility on an in-house designed analog to digital conversion system capable of multiplexing up to eight separate channels of data. Once the data has been digitized, a Fast Fourier transform program is utilized with a Burroughs' B5500 computer to determine amplitude as well as directional power spectra. In addition, significant wave heights and the average of the highest 1/10 wave heights are computed. Plots of the amplitude and directional power spectra are routinely presented (see Figures 3 & 4), and in addition, the user can obtain a listing of the Fourier components. Numerical techniques for the preparation of wave refraction diagrams are also available for the Panama City offshore operating area.

III. OCEANOGRAPHIC MEASUREMENT PROGRAMS.

The Naval Coastal Systems Laboratory has been involved either directly or indirectly in oceanographic studies in the northeastern part of the Gulf of Mexico for two decades. These studies have covered a wide range of oceanographic parameters. From them a substantial resource has accumulated both in technical background information describing the coastal environment in this area and in physical facilities and technical personnel capable of acquiring and processing a wide range of oceanographic information. In addition, on-going oceanographic programs have many facets of common interest to a study of marine environmental implications of offshore drilling in the Eastern Gulf of Mexico.

Several significant programs have been carried out in the past that measured some of the more important hydrodynamical properties that relate to the effects of offshore drilling. These studies have included measurement of internal and surface flow field properties, surface wave studies, including directional analyses, water density structure, wave-wave interactions, tidal flow, large-scale circulation, and many other related areas. Other measurement programs have involved spatial measurements of offshore sediment properties of the coastal shelf and coastal-to-deep-water measurements of the acoustical transmission properties in and near proposed areas of drilling.

Detailed studies have been made of the drift characteristics in this area using drift bottles released from Stage I over a 28-month period. The results indicated that the primary mechanism of surface water transport in this area is wind-induced currents, which either transport the bottles to local beaches or to regions where permanent or semipermanent currents can carry them to the west or east.

Measurements have been made using bottom mounted pressure transducers of the directional properties of surface waves. From results of these tests the refraction of surface waves as they enter shallow waters has been determined. A model is being developed for the prediction of wave modification in shallow water with particular emphasis on Gulf beach areas.

Several studies have monitored the internal flow field over a period of years. The characteristics of both low and high frequency internal waves have been measured and the results indicate that linear internal-wave theory adequately describes the basic internal-wave motion observed experimentally. Studies have also been made of the interaction of internal waves with surface waves. The results support theoretical predictions of dynamical interactions of high-frequency internal waves with short, surface gravity waves.

The results of five years of physical oceanographic surveys conducted in the Gulf of Mexico indicate a generalized semipermanent circulation pattern for the eastern gulf. This current, which extends north to the continental shelf limit just south of Panama City and Pensacola is believed to drive or control the nearshore water motion observed near Panama City.

Results of seven years of data collection of the thermal structure of shallow water reveal that (1) the onset and decay of summer thermal structure are limited at each end of the season by meteorological effects, (2) circulation associated with internal tides is an important factor in maintaining the thermal structure, and (3) the thermal structure in shallow water responds quickly to significant seasonal changes, as well as to local meteorological changes.

Present, on-going programs at NCSL involve monitoring and measuring the directional statistical properties of surface waves and associated meteorological conditions at two offshore towers. Results of this program are being used to correlate with data from sea trials of experimental surface craft for the Navy. This testing activity is expected to expand considerably over the next several years and will also include near-shore monitoring of waves, currents, and wind fields.

A study to measure and record seasonal background acoustic/ seismic noise levels as a function of sea state and to provide a capability of monitoring signals generated by oil/gas drilling operations in the vicinity of NCSL's operating area is presently underway. One hydrophone and one 3-axis geophone form a sensor pair at each of two locations 100 meters, and 1000 meters from Stage I. These data are sent by radio telemetry to a shore based tape recorder. The Burroughs 5500 and Cal Comp plotter provide power spectrum analyses of these tapes.

Also, on-going at NCSL is a study to measure and model sand transport in the vicinity of a coastal inlet at Mexico Beach. Periodic topographic surveys are being made to determine changes in bottom contours. Measurements are also being made of the dynamical forces in this area in the form of wave and current measurements for the purpose of establishing a relationship between these forces and the transportation of sand.

A history of biological monitoring at each of the NCSL test sites provides the beginning of a data base for evaluation of the effects of offshore drilling on coastal ecosystems. Fouling studies conducted in past years at the offshore stages and present monitoring of water quality, plankton, nekton, and benthos along a two-mile coastal segment at Mexico Beach are particularly pertinent to the present concerns.

IV. NAVAL COASTAL SYSTEMS LABORATORY PROPOSAL.

The location of NCSL and its offshore facilities makes it particularly suitable for conducting coastal environmental studies. The determination and monitoring of the offshore dynamical forces in terms of wave energy, currents, internal flowfields, and meteorological forces are necessary in determining the impact offshore drilling in the Eastern Gulf of Mexico will have on the marine environment. To this end NCSL is proposing to measure these forces to analyze the data and to interface with relevant studies conducted by other laboratories and universities. These results will be used to develop models for predicting the interaction of the marine environment and offshore drilling.

The objective of the measurement portion of this study is to monitor continuously at Stages I and II the internal and surface flow field, the water and air temperature structure, surface wave statistics, including height, sea state, direction, and power spectral densities in both height and direction, wind speed and direction, humidity, and pressure. The information obtained will be used to interface with the other measurements being made from ships from other laboratories and universities. These latter measurements will furnish spatial information concerning the processes whereas the NCSL measurements will give the continuous time-history of the various parameters at two offshore locations. Both sets of measurements are required to give the complete time-spatial properties of the environment.

The instrumentation proposed for this experiment includes at both stages: a vertical array of two-component current meters, a vertical array of temperature sensors, two arrays of wave sensor--one array of six bottom-mounted pressure transducers and one array of four surface resistance wave gauges, a vertical array of anemometers, a barometric sensor, and a humidity gauge. The outputs of these instruments will all be transmitted in real time from each stage to NCSL via a telemetry link. Voltage-controlled-oscillators and/or pulse-amplitude-modulation techniques will be used to multiplex the data on one radio channel from each stage.

The multiplexed data received at NCSL will be recorded on magnetic tape at predetermined intervals, the length of each recorded interval also to be determined. The recorded data will be demodulated and digitized in a format compatible for processing either by a Burroughs B5500 digital computer or a Hewlett-Packard HP 10/30 minicomputer located in the receiving facility. Processing of the data will be done by standard data reduction techniques developed and operating presently at NCSL. These will include but not be limited to determining the mean and variance of the measured quantities as a function of time, space and the other associated parameters. In addition, spectral analyses will be performed on a sampling basis to determine the energy content as a function of frequency, time, and space. Directional power spectra will be obtained for the surface waves.

The program proposed is a two-year effort. The magnitude of effort will be determined following the establishment of priorities and the roles of the various Federal and State agencies. Because of the existing programs at NCSL, it will be possible to perform this study at a cost much less than otherwise possible. Over half of the instrumentation already exists and is operating or to be operating in the near future. The processing techniques already exist and are currently being used in similar programs. It is recommended that, if this proposal is accepted, a portion of the funding be made available as soon as practical so that data presently available can be collected and processed in a format useful to this program.

Utilization of NCSL's fixed platform offshore stages, and beach towers scattered through the heart of the threatened shore area are proposed as a basis for an inshore biological sampling program. Expansion of ongoing biological monitoring programs at NCSL test areas provide an ample scheme for shore monitoring for comparison with a pre-established baseline. Sampling at these sites could be economically accomplished by existing NCSL survey teams. Sampling within the offshore drilling areas could best be accomplished by state or university vessels supported by NCSL docking and laboratory facilities. Cost estimates will be presented as specific roles of various Federal and State agencies are defined.

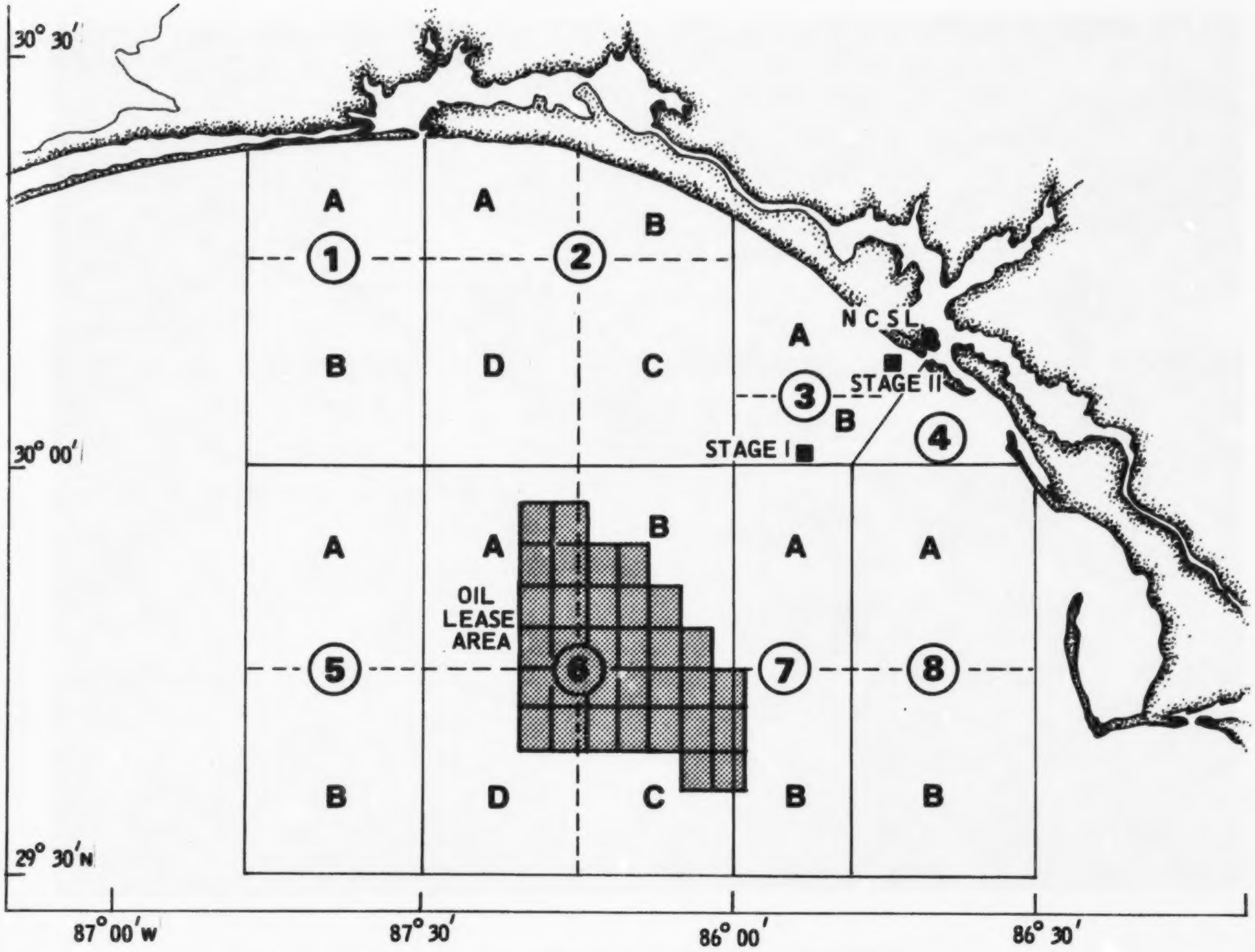
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FIGURE 1. PENSACOLA - SOUTH LEASE AREA

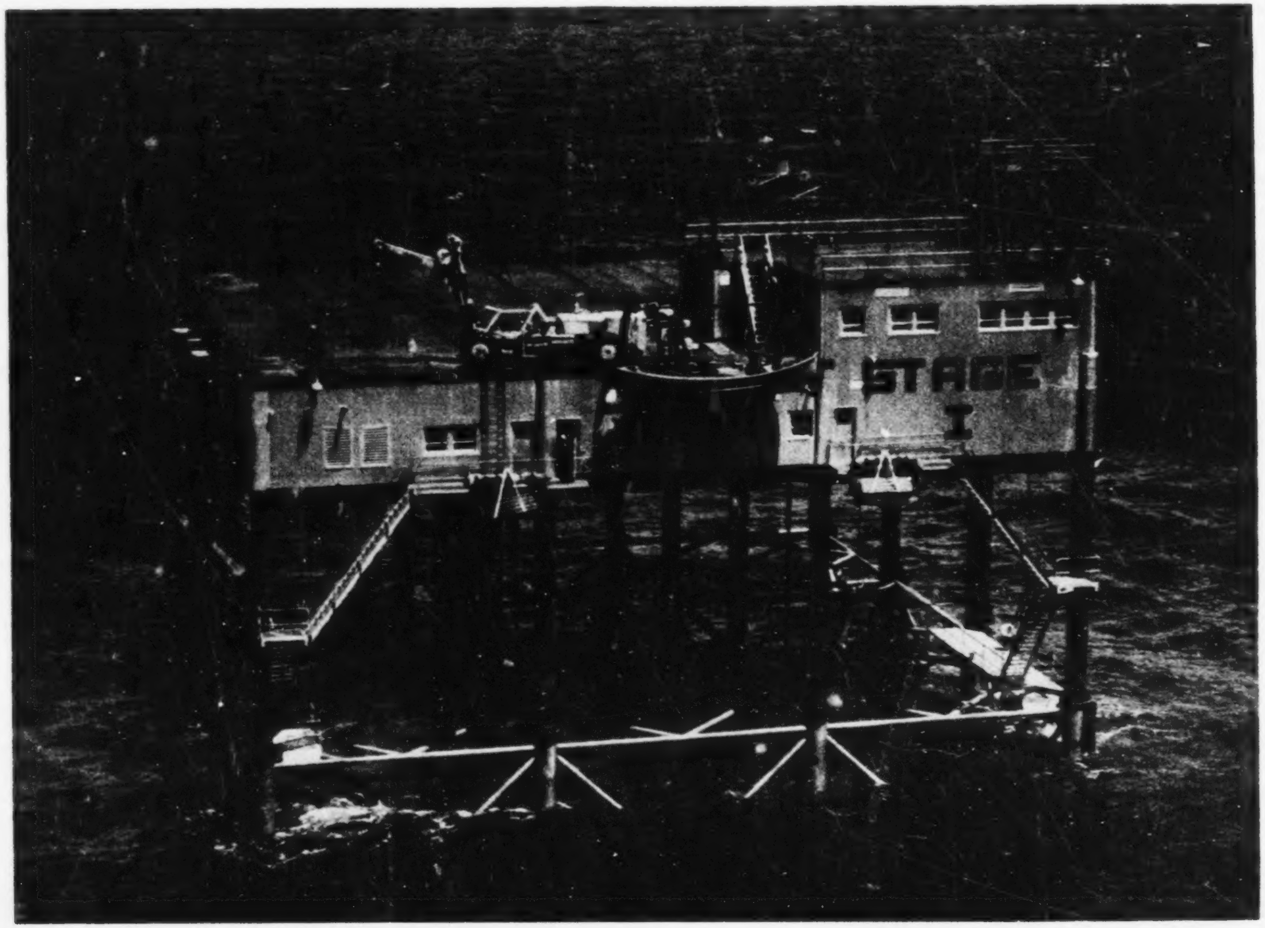


FIGURE 2. OFFSHORE PLATFORM (STAGE I)

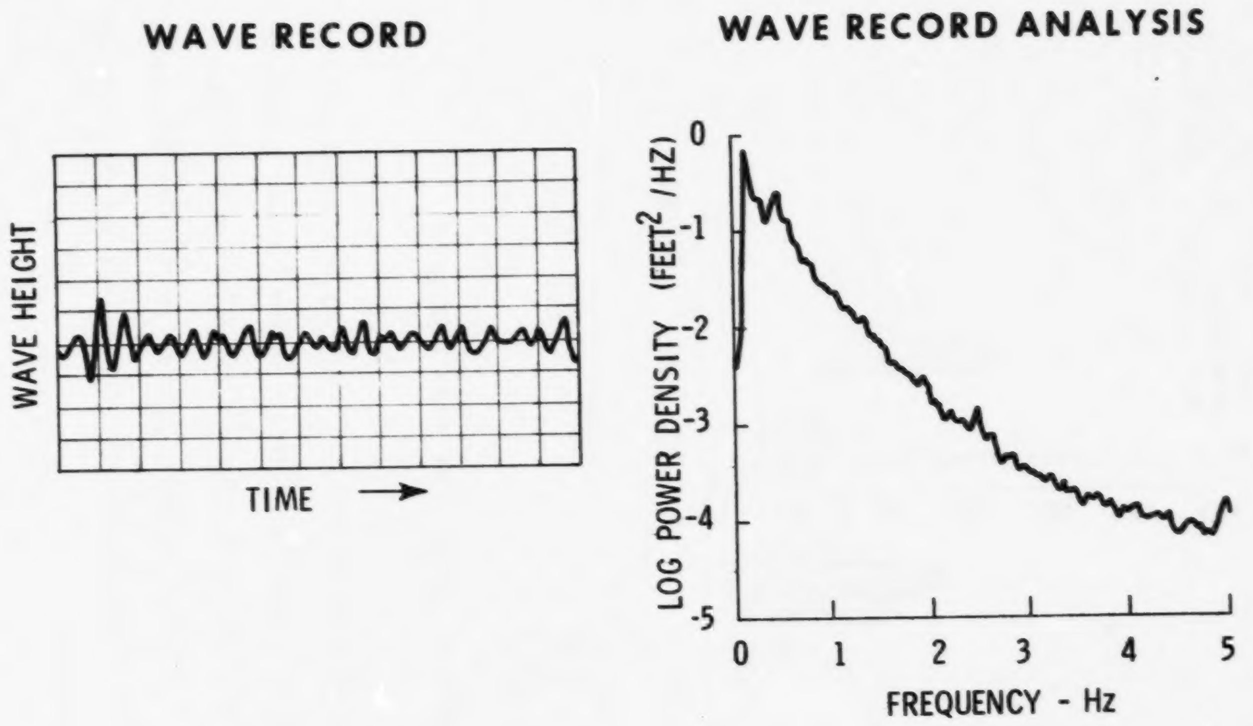
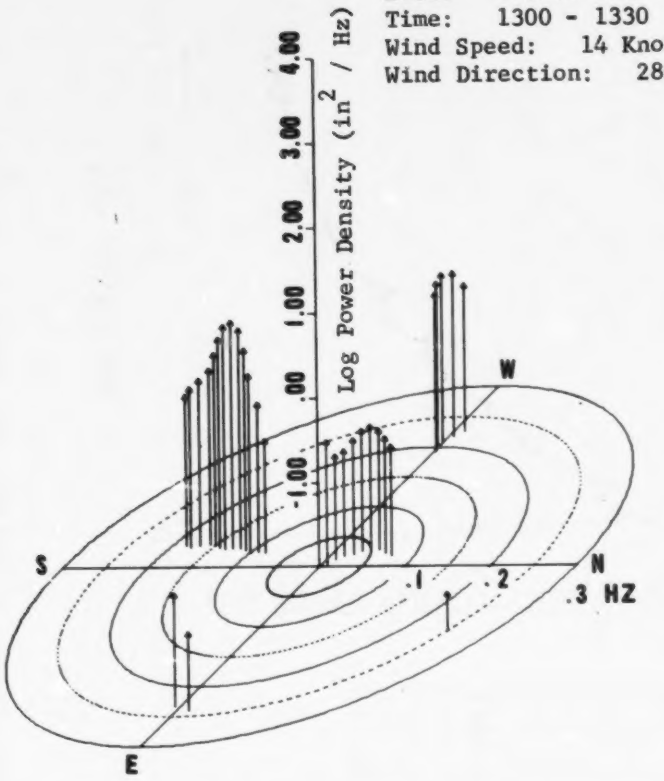


FIGURE 3. TYPICAL POWER SPECTRAL DENSITY OF SURFACE WAVES MEASURED AT STAGE I



Stage II
Date: 4 June 1965
Time: 1300 - 1330
Wind Speed: 14 Knots
Wind Direction: 280 Degrees

FIGURE 4. DIRECTIONAL POWER SPECTRA

The bottom of the arrow gives both the frequency and bearing of the waves. Note that the frequency increases in the form of concentric circles moving outward from the center. The direction north (N) represents magnetic north. To obtain true north one adds 3 degrees. The tip of the arrow indicates the log power density of the waves at the depth of measurement.

A Numerical Model of the Gulf of Mexico Circulation

James J. O'Brien and John C. Kindle
Departments of Meteorology and Oceanography
Florida State University
Tallahassee, Florida

We are constructing a three-dimensional numerical model of the general circulation of the Gulf of Mexico with particular interest in studying the dynamics of the Loop Current and its effect on the near-shore circulation, We will use a time-dependent, multilayer x-y model in which we assume the fluid to be both hydrostatic and Boussinesq. The model equations are integrated vertically in each layer and include the effects of horizontal advection, pressure gradient forces, rotation, surface interfacial and bottom stresses, horizontal friction, bottom topography, and planetary vorticity advection. In solving these equations numerically, the model will utilize the highly desirable feature of variable resolution which allows us to place a fine grid in the vicinity of interest (where the action is) and a coarser grid elsewhere.

The Gulf of Mexico is an ideal basin to which to apply and develop numerical models for the general circulation of oceans. Its limited size and well-defined boundaries are particularly desirable features. The Gulf is an enclosed two-port basin with approximate dimensions of 1500 km by 900 km, by 3 km. Virtually all the transport into the Gulf is through the Yucatan Straits while outflow is through the Florida Straits, the steady state magnitude of which has been found by Schmitz and Richardson (1968) to be $32 \pm 3 \times 10^6 m^3/sec$.

The major circulation feature of the Gulf, the Loop Current, is a swift, highly variable in time current. It consists of the inflow through the Yucatan Straits known as the Yucatan Current, the extension of this flow into the Gulf forming an anticyclonic loop, and the subsequent outflow through the Florida Straits initiating the Florida Current. Typical speeds of the Loop Current are on the order of two to three knots; the width of the main axis of the current varies from 50 to 100 km while the width of the entire loop is as much as 300 km. The primary forcing mechanism for this current system is generally considered to be the inflow through the Yucatan Straits; although winds may occasionally affect the circulation patterns of the Gulf, such as during hurricanes, it is not believed that the major circulation features of the Gulf are wind driven.

Theoretical studies of the Gulf circulation have been aided by some excellent observational work documenting the general behavior of the

Loop Current over a year and a half period at approximately three-month intervals (Leipper, 1970). It was found that the Loop Current changed considerably over this period. Leipper observed in general that although the extension of the loop well into the Gulf does not appear to be rigidly seasonal, maximum intrusion usually occurs in the fall after strengthening during the winter and spring seasons. After maximum intrusion occurs, several distinct events are then possible. The first is that the loop may become closed at some point and form an eddy which detaches from the mainstream of the current. Descriptions of these events have been given by Nowlin et al. (1968) and Cochrane (1972). The dynamics of these eddies are not well understood; it is believed that they migrate to the west while experiencing a slow decay. If a detached eddy is not formed, then the loop may remain relatively stable downstream while migrating slightly towards the west. The particular mechanisms generating the behavior described above are still not clear.

The model will be used to investigate such phenomena as the initial formation of the loop, the extension of the loop well into the Gulf, the formation of detached eddies, the dependency of the Loop Current on the spatial distribution and the temporal variability of the specified inflow at the Yucatan Straits, and the effects of the Loop Current on the near-shore circulation. Although wind effects may be easily incorporated, we initially intend to force the model only by the specification of the transport through the Yucatan Straits; the transport through the Florida Straits will be determined by the model. Utilization of variable resolution in the numerical scheme will allow us to place a fine grid in the vicinity of the Loop Current and a coarse grid throughout the rest of the Gulf. Furthermore, the efficiency of our numerical scheme will afford us the opportunity to perform a substantial number of parametric studies as a further aid in elucidating the physics of the problem.

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NOAA's Environmental Data Index (ENDEX)

Robert V. Ochinero
NOAA/Environmental Data Service
National Oceanographic Data Center
Washington, D. C.

Scientists, managers, and decision-makers at all levels of government are increasingly dependent upon and concerned about the amount and quality of environmental data and information available for consideration in the decision-making process. Such data are available only if someone other than the local holder of the data file knows of its existence.

The research community is rather well served by its specialized bibliographic and abstracting services. Even "research in progress" is documented at the federal level through the Science Information Exchange of the Smithsonian Institution. In the area of environmental data files, sample collections and specialized sub-discipline reference library collections, it is becoming increasingly important that the existence, scope and documented content of these files or holdings be made more widely known, so that they need not be unnecessarily duplicated and so that their content may be more widely appreciated. Holdings, in many cases, are inventoried, indexed, and even documented on a local basis. What is needed might be described as a centralized index, and for convenience supported by an automated information retrieval system so that specific referrals may be made rapidly, effectively and inexpensively.

The heart of any such system is the information it contains. The most difficult part of establishing such a system is locating and cataloging the files whose indexes will be the system.

What Is ENDEX?

The Environmental Data Service (EDS) has established an automated, documented, comprehensive index describing environmental data collections. This Environmental Data Index (ENDEX) enables scientists and managers to answer such questions as: who has a certain kind of data in a particular area; how was it collected; what form (medium) is it in; who sponsored the activity? In some cases the data may be selectively accessioned by the EDS or other appropriate national repository but that is not the primary goal.

How Broad Is ENDEX?

The concept of ENDEX includes descriptions of data collections, detailed inventories of very large environmental data files, and descriptions of available files of data.

What Types of Data Are Being ENDEXed?

Data which have been submitted to national archives are either already in a fully retrievable form or are being ENDEXed at these centers as an interim measure. Ideally, all collection activities will be contacted and all types of environmental data will be included. The emphasis is on data files; therefore, only those projects involving the measurement of environmental variables are relevant. Initial ENDEX efforts are focusing on environmental data representing the more classical physical, chemical, and biological measurements of air, land, water, flora, and fauna samples. ENDEX also contains information on the location, scope, and content of permanent sample (biological, geological, etc.) and photograph collections, whether they have been fully analyzed or not.

What Type of Information Is Coded to Describe Available Files of Data?

The following is a general list to demonstrate the types of information and level of detail desired.

Institution
Date(s)
Location (s)
Parameter(s)
Measurement method(s)
Number of observations
Data media
Project affiliations
Person to contact to obtain data
Publications resulting from data
Funding agency
File size
Abstract

Some of the above values are selected from a thesaurus which controls spelling and spacing of these values on input thereby making retrieval, sorting and manipulation by applications programs easier.

How Are Descriptions of Files Gathered?

In order to assure a uniformity of approach, level of detail, and use of key words, a small number of interviewers familiar with the disciplines and problems of the area are being trained for ENDEX and sent into the field.

Must Data Be Available?

Yes, but contributors may qualify availability as below:

1. User must pay reproduction and labor costs.
2. Samples may only be studied at the archive location.
3. Data will be available at completion of project in ____________________.
4. Other.

Is the ENDEX Available to Contributors?

Yes. Agencies supplying information to the inventory are allowed to interrogate these files through EDS. Because the system is fully automated, response time is rapid. In addition, printed indexes will be produced for geographic areas and disciplines when demand is sufficient.

How Detailed Is the Index?

The index has a separate entry for each variable measured by a single method for a period of time. The coding of time period may vary at the discretion of the interviewer (i.e., a sensor running continuously except for maintenance for several years will be one entry but one used sporadically over several cruises might require many entries).

Sample collections are classified only generally as to type of sample (plankton, sediment, fish, etc.), type of sampler (Clark, Bumpus, vertical tow, .25 mm mesh) and time period (6 cruises over a 3-year period, 1969-71). Other information is included as appropriate (location, height or depth of sample, etc.).

How Is Textual Uniformity Attained?

Key word retrieval imposes the restriction that information must be coded identically on all forms. For example, if one form lists "total organic carbon" and the next "carbon, organic total," retrieval on any single word would be successful, but retrieval on a combination (i.e., "Organic Carbon") would yield only partial success. Therefore, a thesaurus has been developed to provide proper parameter designations. Other important fields such as institutions, dates, methods, platforms, etc. are also included in a controlled vocabulary.

How Will ENDEX Be Updated?

After the initial description of files of environmental data, an output will be distributed every two years to each contributor for updating in terms of content, availability, and changes. New files will also be flagged for description at this time.

Environmental Data Index (ENDEX) For Florida
Progress Report

NOAA's Environmental Data Service (EDS) is currently inventorying oceanographic, estuarine, fishery, meteorological, and ecological data files in the State of Florida. This is being done as part of EDS' national ENDEXing effort, and as a cooperative venture with the State University System of Florida Institute of Oceanography (SUSIO).

Florida's (and other states') environmental data are archived by a number of federal and state agencies, including EDS' National Oceanographic Data Center (NODC), National Climatic Center, and National Geophysical Solar-Terrestrial Data Center, as well as the Environmental Protection Agency, the Department of the Interior, and the Army Corps of Engineers.

Although a number of organizations (Council on Environmental Quality, Library of Congress, etc.) have compiled inventories and listings of government agencies archiving and disseminating environmental data, these tend to describe organizational structure, rather than data files. Under ENDEX, EDS is compiling a detailed inventory of actual environmental data files themselves, indexed by parameter type, time period, collector, geographic region, and a number of other items.

The ENDEX Environmental Data Base Directory for Florida (EDBD) is being compiled by the NODC Southeast Liaison Officer, a part-time assistant, and a representative of SUSIO. Florida is the fourth major geographic area to be ENDEXed by EDS. Previous areas ENDEXed include the Great Lakes, Chesapeake Bay, and the New York Bight region.

The Florida ENDEX timetable is flexible and oriented to available resources and national priorities. Under the present schedule, work should be completed by 1977. At that time (in some cases earlier), a number of ENDEX products will be available, including a hard-copy listing of data file sources indexed by parameters and geographic locations. An interactively searchable file of data descriptions will be accessible from terminals located at the Liaison Office in Miami and the SUSIO office in St. Petersburg.

The Environmental Data Service's Southeast Liaison Officer is currently describing files at the following activities:

AOML (NOAA)
SEFC (NOAA)
Panama City Lab, Department of the Interior
Naval Coastal Systems Lab (Department of Defense)
EPA, Perrine
EPA, Pensacola
National Park Service (Everglades)
University of Miami
Nova University
Harbor Branch Research Foundation
Florida Institute of Technology
Perry Submersible Industry
Jacksonville University

SUSIO is describing files at the following activities:

Florida International University
Florida Atlantic University
University of South Florida
Florida Technological University
University of Florida
University of North Florida
Florida State University
University of West Florida
Miami-Dade Junior College
Key West Junior College

In addition, discussions have been conducted with the Florida Coastal Coordinating Council about inventorying state agencies using ENDEX procedures. Agreement has been reached in principle, but no work is yet under way. State agencies that will be contacted include:

State of Florida Department of Natural Resources
  Marine Resources Division
  Recreation and Park Division
  Game and Fresh-Water Fish Commission
State of Florida Pollution Control Department
Regional Planning Offices in Dade, Broward, Hillsboro, Pinellas, Santa Rosa, Martin, Duval, Sarasota, Bay, Manatee, and various other counties

At a later date efforts will also be made to contact major industrial environmental data producers such as the Florida Power Corporation, the Florida Power and Light Company, and commercial aquaculture industries.

Finally, to assure completeness of ENDEX data file descriptions for the State of Florida, institutions outside the state will be contacted as a part of EDS' national ENDEX efforts.

Text of Letter From Ralph W. Schreiber (USF)
to Robert Smith (SUSIO); subject, Marine Birds
January 25, 1974

This letter is to suggest that BIRDS are a subject deserving some priority in the interdisciplinary program which is to be developed at the Conference/Workshop concerning the Outer Continental Shelf oil exploration and production activities. I suggest several reasons why the birds of the Gulf of Mexico deserve attention in this program.

1. As noted by Woolfenden and Schreiber (1973, SUSIO-API), essentially nothing is known about the marine birds inhabiting the Gulf. There are few published data on species composition and numbers present in the region, and of course nothing is known about the dynamics of the birds in the ecosystem. Birds are probably as poorly known a taxa in the region as exists.

2. The marine birds inhabiting the region subsist entirely on fish and squid and thus are situated at the top of the marine animal food chain. Data on bird flocks often are useful in determining fish school locations and the bird dynamics are directly related to oceanic productivity and current systems. Thus, the possible interactions in which study of the birds would be useful in the interdisciplinary study are numerous. In addition, we do know that several species of marine birds are extremely sensitive to some forms of pollution and thus they provide us with a valuable indicator-species of the quality of the marine environment.

3. Bird migration across the Gulf of Mexico has been studied extensively on the coasts of the Gulf, but little or no information has been collected about this migration from the sea. Migration is an area of continuing interest and studies of bird migration from permanent locations at sea would be extremely valuable.

4. My fourth point is not purely in the realm of scientific study, but perhaps is just as important in the "big picture", if for only its public relations value: nothing fires the people's emotions more than birds covered with oil. No matter how excellent the preventative mechanisms, oil spills will occur and birds will become oiled as a result of operations in the Gulf. I believe it will be very beneficial for us to know as much as possible about the birds in the region so that this can be used in event of an oiling situation arising.

The cost of studying the bird populations of the Gulf of Mexico would be minimal compared to other studies. Since towers and ships will be available for the other studies and for drilling operations, bird studies can be carried out for little more than salary and stipends.

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Because of prior commitments, I am unable to attend the Conference and February 1 Workshop. I will be present on February 2.

I am anxious to help developing a program of the birds of the Gulf of Mexico and look forward to discussing the subject with you.

Hydrographic and Current Structure on the Western Continental Shelf of the Northeastern Gulf of Mexico

William W. Schroeder
George F. Crozier

Marine Science Program
University of Alabama
Dauphin Island Sea Lab
Dauphin Island, Alabama

The interest developing in the offshore areas of Mississippi and Alabama stimulated a series of cruises in 1973 by personnel from the Marine Environmental Sciences Consortium (MESC). The Alabama Estuarine and Continental Shelf Oceanographic Survey (AECSOS) has been concerned with the relationship of Mobile Bay to Mississippi Sound and the continental shelf, as well as the areas involved in the possible "superport". Recent support to the University of South Alabama will extend these activities to the east toward Panama City.

Development of the AECSOS program has led to the establishment of several standard cruise tracks (Fig. 1). The north-south oriented transects were designed for completion within 30 hours which will allow semi-monthly sampling with at least four anchor stations. Time did not allow the reduction of all existing data but hydrographic and current data taken during R/V Aquarius cruise A-73-36 (July 1, 1973) are presented. The cruise track (Fig. 2) covered the inner continental shelf from Petit Bois Pass to 25 miles northeast of the Mississippi Delta. Table 1 lists the positions of A-73-36 hydrographic stations. Hydrographic data consist of 20 expendable bathythermograph (XBT) stations, 4 depth-oxygen-temperature-salinity (DOTS) stations and 2 surface water sample stations. XBT data were taken with a Sippican Shallow-water R-603B System. DOTS data were obtained with a Hydro-Lab Corporation Surveyor system. Circulation measurements were made at hydrographic stations 1, 2, and 4 utilizing an Environmental Devices Corporation Type 110 Remote Reading Current Meter while the Aquarius was anchored.

SURFACE TEMPERATURE AND SALINITY PATTERNS: The observed surface-temperature field, constructed with surface bucket-thermometer data, reflected the diurnal solar cycle. Temperatures increased during the day and decreased at night. Temperatures ranged from 28.4 to 31.2°C. The lower values were all associated with low salinity water with a dominant river run-off origin while the higher values were associated with higher salinity water of northeastern Gulf of Mexico origin.

The observed surface-salinity field is shown in Figure 3. It is constructed from conductivity measurements made with the Surveyor system on surface water samples. The major features consist of two low salinity lenses separated by a tongue of intermediate salinity water. Heavy rainfall and record river discharge are responsible for the low salinity features. The origin of the two low salinity lenses are presumed to be the west Mississippi Sound-Chandeleur Sound area for the northern lens and the East Mississippi Delta area for the southern lens. If this is correct, then the position of the lenses indicates a general eastward drift of surface waters.

SUBSURFACE WATERS: Temperature sections, constructed from XBT data, indicate that the study area is divided vertically into 3 thermal features: (1) a surface layer, 0-8 meters in depth with a temperature range of 28.0 to 31.2°C; (2) a pycnocline zone, 8-12 meters in depth with a temperature range of 24.0 to 28.0°C; and (3) a bottom layer from 12 meters to bottom depths of 22-47 meters with a temperature range of 19.1 to 24.0°C. Figure 3 shows the vertical distribution of temperature, salinity and oxygen for the DOTS data at the four Hydrographic Stations. All stations exhibit a relatively sharp boundary at the pycnocline zone. The surface waters at all stations are characterized by warm temperatures, salinity values between 22 and 30 °/oo and a dissolved oxygen maximum zone with values greater than 8 ppm. The pycnocline zone consists of a marked thermocline and halocline and an area of rapid oxygen depletion. The bottom layer is characterized at all stations by a stable--decreasing with depth--temperature structure, a nearly isohaline salinity structure and a dissolved oxygen profile with a mid-depth secondary maximum and an on-the-bottom minimum value.

During collecting and photographing,SCUBA diving operations scientist-divers recorded moderate turbidity at the surface increasing to a maximum turbidity at the pycnocline, which limited visibility to less than one meter. Visibility improved dramatically immediately below the turbid pycnocline water and remained good until the last meter when some suspended sediment was encountered. The pycnocline zone acts to trap and concentrate both the organic and inorganic material sinking through the surface layer. It also tends to concentrate living organisms by acting as a barrier to upward and downward migrations. The decomposition of the organic matter and the respiration of the living organisms at the pycnocline are the primary causes for the rapid oxygen depletion in this zone.

CURRENTS: Direct current measurements gave no indication of any sustained unidirectional horizontal water movements. However, significant tidal currents were measured. Figure 5 illustrates the current meter data. A two-layer system is clearly evident. The less saline surface layer, which is so apparent in Figure 3, is shown moving 90 to 120° off and 0.1 to 0.7 knots faster than the bottom, more saline, layer. The clockwise current direction of both layers changing with time is accounted for by the fact that in the open ocean, in the absences of wind or nontidal currents, tidal currents exhibit rotary patterns as a function of tidal cycles. The different current speeds observed are also related to the tidal cycle. Figure 6 represents a tidal curve calculated for the study area by making a composite of the tidal curves predicted for the shore stations at Horn Island Pass and Ship Island Pass, Mississippi, and Pass a Loutre Entrance (Mississippi River), Louisiana. Note that station 1 was occupied at the beginning of flood tide close to high water and station 4 well into ebb tide.

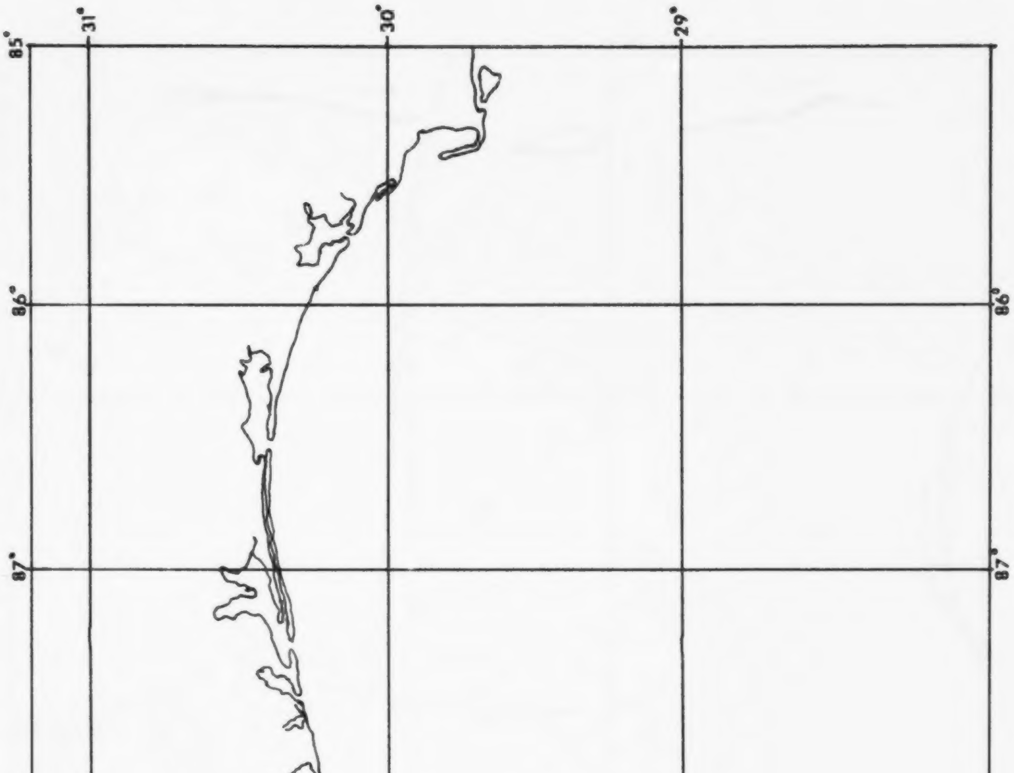
METEROLOGICAL DATA: On the Beaufort Scale, wind and seas ranged between 0 to 3: calm to gentle breezes and flat to one foot waves. Wind direction was variable. Sky cover was clear to scattered cirrostratus clouds. There was no precipitation.

PROSPECTUS: Consideration of these and other data (ESCAROSA,NASA-ERL) indicates the need for additional work in several specific areas. One is the effect of the Mississippi River and Mobile Bay on shelf waters to the east, and from the other direction the effect of intrusions of the Loop Current into the area.

In order to broaden the data base, the anchor stations of the AECSOS second year will include profiling of nitrate, phosphate, chlorophyl and extinction coefficient. The University of Alabama Marine Science Program is currently maintaining data buoys in the main passes of Mobile Bay which are telemetering salinity, temperature and current data to the Earth Resources Technology Satellite and to a base station at the Dauphin Island Sea Lab. All these efforts will be coordinated with biological sampling by MESC personnel and in cooperation with projects of the Mississippi-Alabama Sea Grant Program. We anticipate that these data will provide the necessary baseline information for the area and quantify the interactions of the coastal waters and those of the open Gulf of Mexico. It is this type of approach which provides the information useful in assessing the productivity and resources as well as developing a predictive capability with regard to environmental impact of industrial use of the area.

A-73-36 Station Numbers	Position		Depth (Meters)	Corresponding Superport Site Stations
	North Latitude	West Longitude		
1	30° 30' 00"	88° 18' 00"	49.4	---
2	29° 38' 20"	88° 30' 40"	36.6	5
3	29° 44' 30"	88° 23' 15"	34.7	4
4	29° 47' 10"	88° 16' 00"	36.6	3

Table 1. Positions and depths of Aquarius A-73-36 hydrographic stations and the corresponding proposed Superport site stations.



31°
30°
29°
85°
86°
87°
88°
89°

Fig. 1.

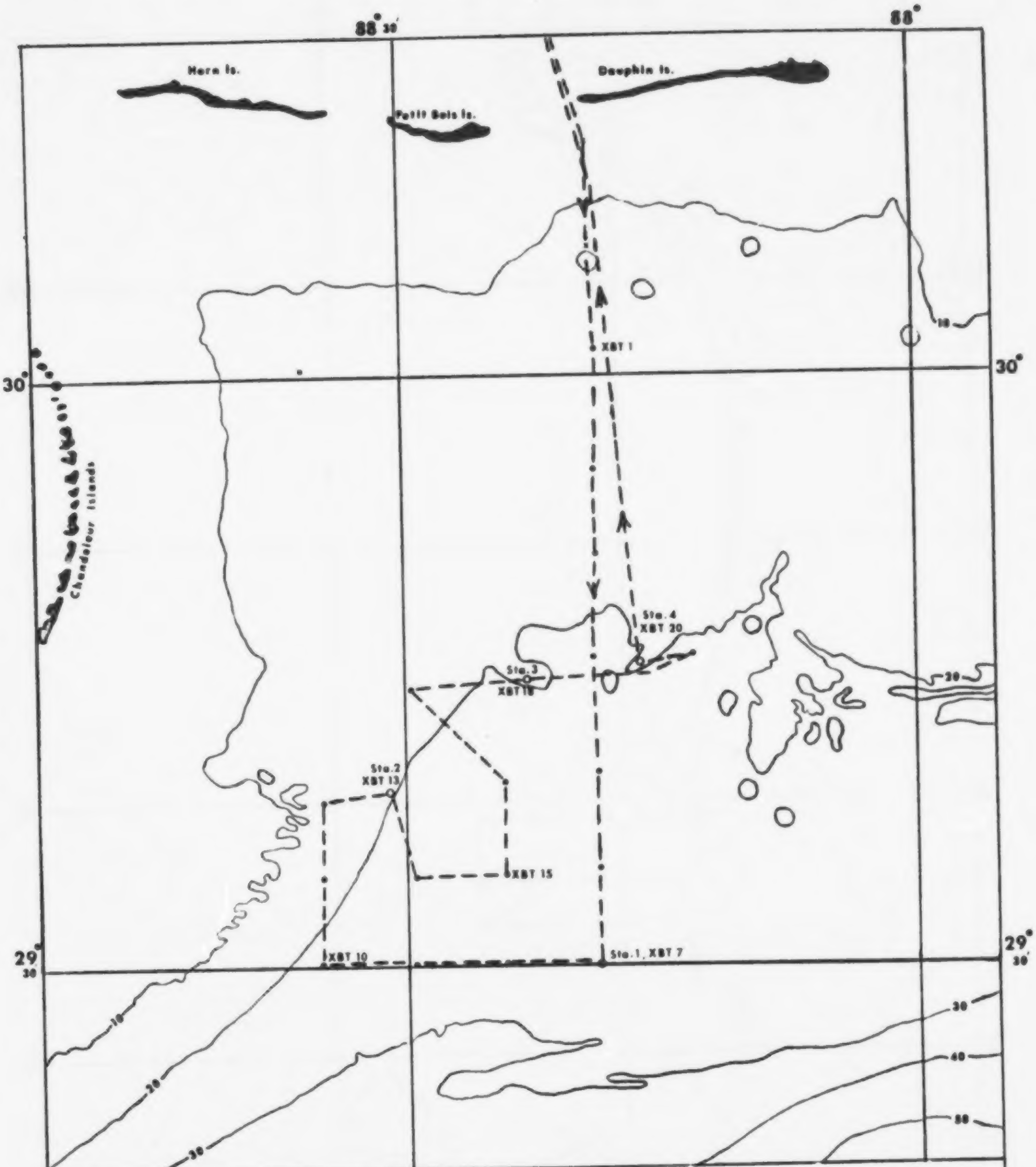

88° 30'
88°
Horn Is.
Petit Bois Is.
Dauphin Is.
Chandeleur Islands
30°
30°
XBT 1
10
Sta. 4
XBT 20
Sta. 3
XBT 18
20
Sta. 2
XBT 13
XBT 15
XBT 10
Sta. 1, XBT 7
29° 30'
29° 30'
10
20
30
30
40
50

Figure 2. AQUARIUS A-73-36 cruise track and station locations.

× Surface Sample
○ Hydrographic & Current Station
• XBT
Depths in Fathoms

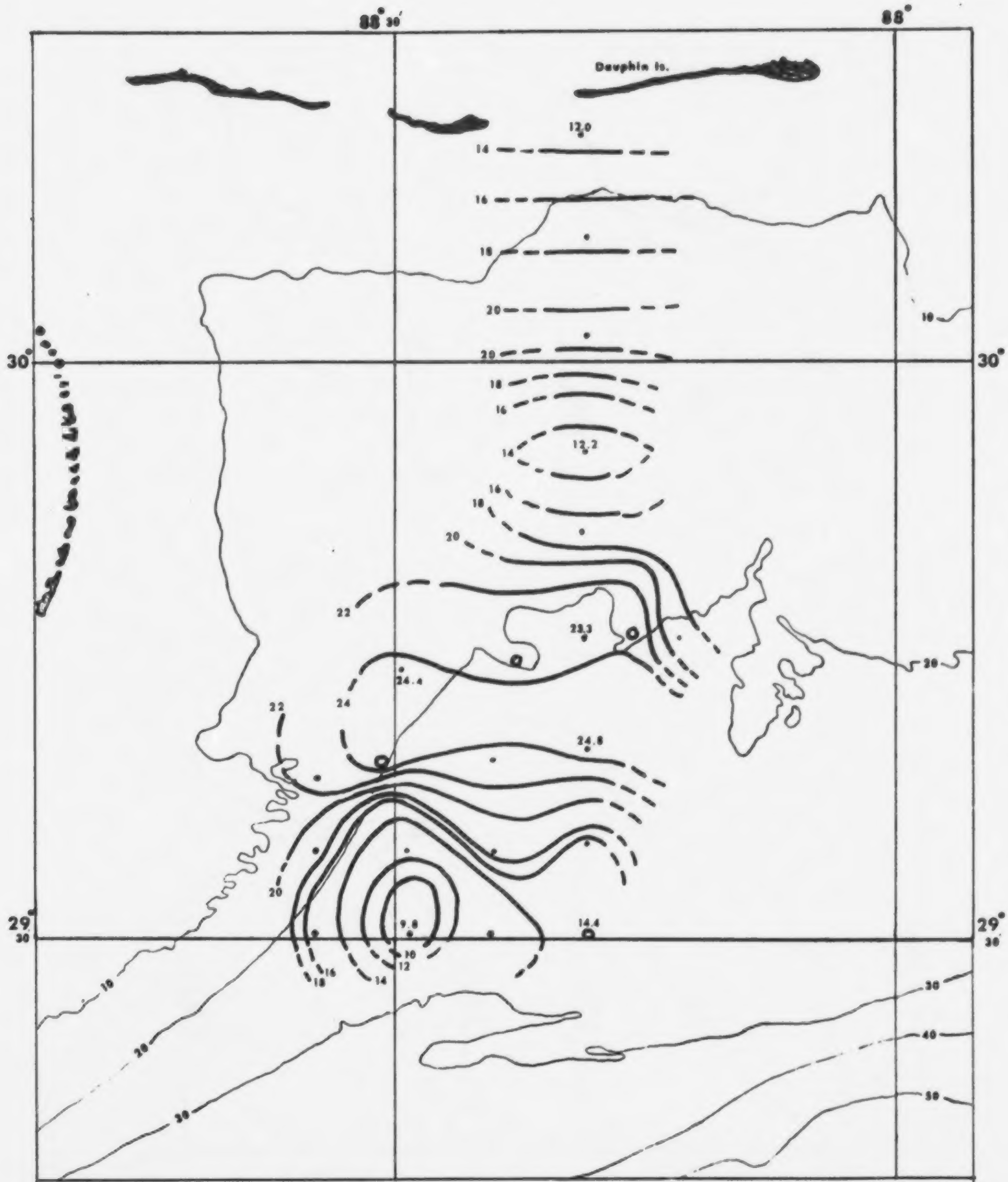

88° 30'
88°
Dauphin Is.
30°
30°
29° 30
29° 30
12.0
12.2
23.3
24.4
24.8
9.8
14.4
14
16
18
20
22
24
10
12
30
40

Figure 3. Surface salinity (parts per mil) as observed during AQUARIUS A-73-36.

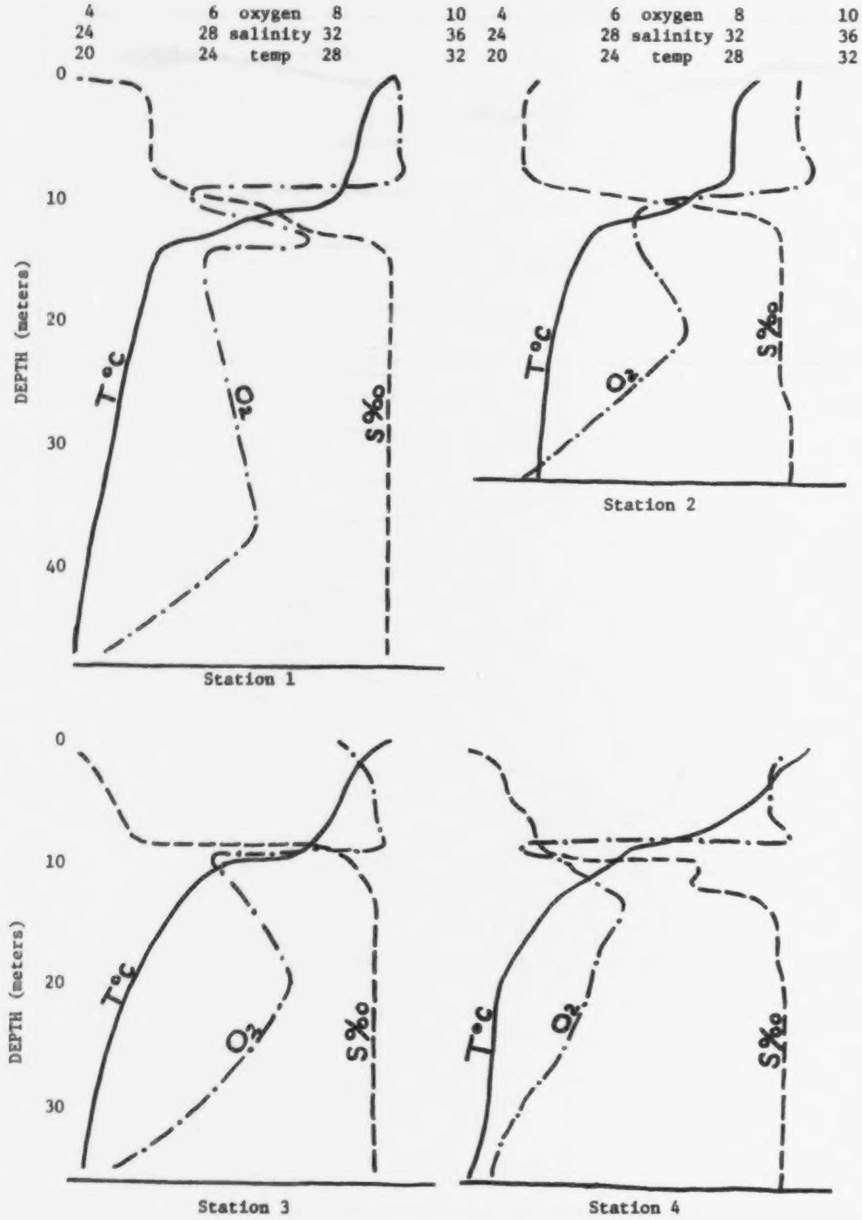
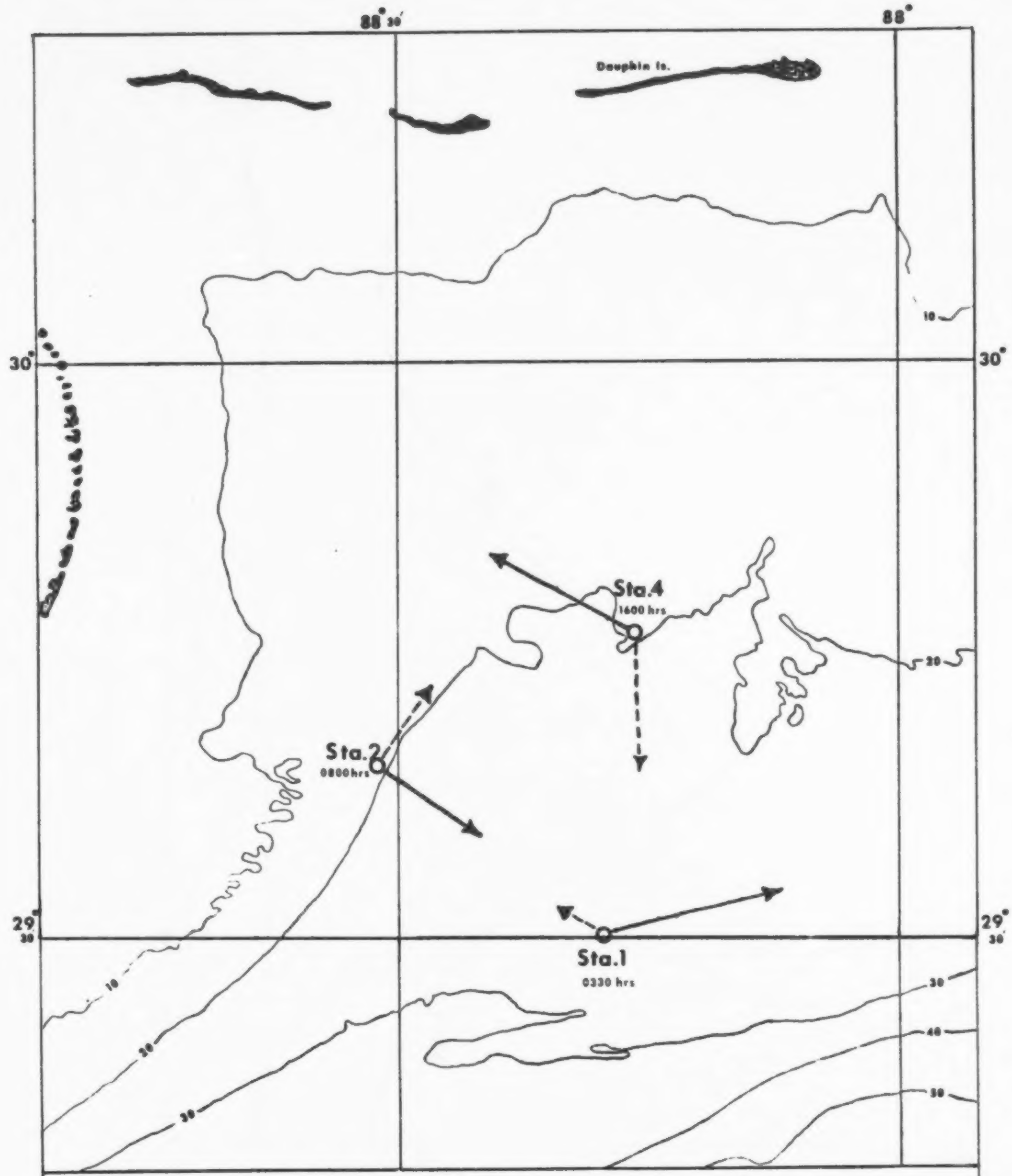


Figure 4. Vertical profiles of temperatures (degrees celsius), salinity (parts per mil), and oxygen (parts per million) for AQUARIUS A-73-36 hydrographic stations.



88° 30′
88°
Dauphin Is.
30°
30°
10
20
Sta.4
1600 hrs
Sta.2
0800hrs
29° 30′
29° 30′
Sta.1
0330 hrs
10
20
20
30
40
50
0 - 8m
10 - 25m
0
.5
1
Knots

Figure 5. Current speed and direction for AQUARIUS A-73-36 survey area during July 1, 1973.

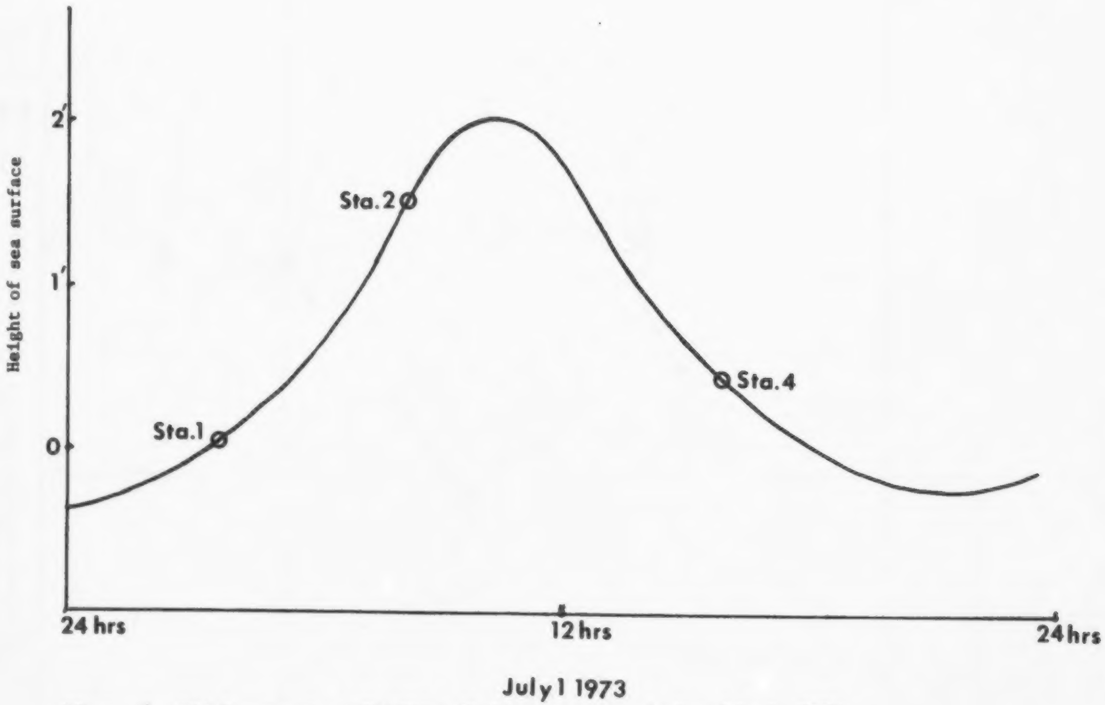


Figure 6. Tidal curve for AQUARIUS A-73-36 survey area during July 1, 1973.

Synopsis of a Report on
A Summary of Knowledge of the Eastern
Gulf of Mexico

Coordinated by
State University System of Florida Institute of Oceanography
St. Petersburg, Florida

Now available to students, scientists, and interested members of the public is an environmental report titled "A Summary of Knowledge of the Eastern Gulf of Mexico - 1973." Compiled and published by the State University System of Florida Institute of Oceanography (SUSIO), the work consists of separate but related reports written by 22 authorities in the field.

Expanded development of resources and increasing use of the Eastern Gulf wetlands and offshore areas pointed to the need for an up-to-date assessment of the region's environmental characteristics so that measures can be taken to adequately protect them. It was in response to this need that the API Subcommittee on Fish, Wildlife and Conservation contracted with SUSIO to compile and publish the most comprehensive study to date on the environmental characteristics of the Eastern Gulf as they are presently known.

Since its publication in July of 1973, "A Summary of Knowledge of the Eastern Gulf of Mexico - 1973" has been widely acclaimed. More importantly, it is being used by industry and by local, state, and federal agencies undertaking environmental studies and conservation programs. The entire stock of 1500 copies available through SUSIO has been depleted. Copies are still available upon request from the American Petroleum Institute at 1801 K Street, N. W., Washington, D. C. 20006.

The 540-page, paper-bound volume is divided into major sections on the physical environment of the Eastern Gulf, including climate, physical and chemical oceanography, hydrology of the bays, estuaries, and nearshore areas, and geological oceanography. Also covered are the biological environment, including salt marshes, algae, seagrasses, mangroves, plankton, invertebrates, fishes, marine mammals, and birds; utilization of marine and coastal resources, including fisheries and wetlands; recreation and industrial resources of the coastal zones; and environmental quality problems, including those generated by hurricanes, dredge and fill operations, industrial pollution and sewage contamination, and beach erosion and coastal engineering.

Very importantly, the report documents the wide variety of studies done to date. Consequently, results of future studies can be compared with this baseline report to see what changes are occurring and at what rate, either as a result of natural phenomena or man's activities. The report also identifies areas in which further research may be desirable.

The climate of the Eastern Gulf, which is discussed by Dr. Charles L. Jordan, Professor of Meteorology at Florida State University, is dominated by a subtropical high-pressure belt throughout the year. Wind circulation is generally from the south during spring and summer; in the late fall and winter, there is a prevailing flow from the north. Moderate seas exist over the Gulf most of the year. Hurricanes pose a definite threat to the area from June until late October, with the month of September recording the peak of the season. A total of 216 hurricanes passed through the area in the period 1901-1971, an average of about 3 a year. Over most of the area, mean temperatures vary from a high of about 83 degrees in midsummer to about 70 degrees in midwinter. At Tampa, Florida, extremes range from 22 degrees F to 98 degrees F. Precipitation in the Eastern Gulf area is almost always in the form of rain or drizzle; snow and hail occur rarely. Coastal weather stations show a rather wide range of annual precipitation--at Pensacola, Florida, annual rainfall has varied from as little as 29 inches to as much as 90 inches, with the mean annual precipitation being 63.4 inches.

Dr. James I. Jones, Associate Professor of Geological Oceanography at Florida State University, discusses the physical oceanography of the Eastern Gulf. He points out that the continental shelf extending along the north and east sides makes up about 22 per cent of the total area of the Gulf. Knowledge of currents in the Gulf helps explain the location of prime commercial and sport fishing grounds. For example, the Caribbean Current enters the Gulf through the Yucatan Channel to form a Loop Current that rotates clockwise in the Gulf. Plankton concentrate along the interface or boundary of the Loop Current. These plankton are the base of the food chain for predator fish. When the pattern of the Loop Current changes, the prime fishing areas change. About 25 to 30 million cubic meters of water per second flow into the Gulf through the Yucatan Straits and out through the Straits of Florida. In comparison, the amount of water discharged into the Gulf by the Mississippi and other rivers is small, being about 25,000 cubic meters a second. Tides in the Gulf of Mexico are generally diurnal and average only one or two feet. Upwelling, the vertical motion of water bringing subsurface water to the surface, can extend for hundreds of miles. It introduces large quantities of nutrients to the light zone, resulting in high organic production.

Dr. J. J. O'Brien, Professor of Meteorology and Oceanography, and Dr. Y. Hsueh, Assistant Professor of Physical Oceanography, both at Florida State University, discuss numerical models of the physical environment and a mathematical description of the circulation of waters on the Florida West Coast inner shelf. Numerical models can be quite important in predicting perturbation of circulation. The circulation patterns directly influence ecological conditions and transport of pollutants in coastal waters.

In the report on chemical oceanography, Dr. Eugene F. Corcoran, Associate Professor of Marine Chemistry, Rosenstiel School of Marine and

Atmospheric Science, University of Miami, points out that most of the chemistry of the Gulf has been done in connection with the study of the Loop Current, and consists mainly of measurements of salinity, temperature, and oxygen. Dr. Paul LaRock, Assistant Professor of Oceanography, Florida State University, and Mr. Henry L. Bittaker, from the same institution, summarize data on the chemical characteristics of estuaries. They report that nitrogen and phosphorous enter the water from the atmosphere, municipal and industrial wastes, fertilizers, and animal wastes. The Mississippi River exerts a major influence on the transportation of phosphorous into the Gulf.

Bays, estuaries, and nearshore areas of the Eastern Gulf are shallow (less than 20 feet), well-mixed bodies of water flushed by tidal action and the throughflow of fresh water. Dr. Bernard E. Ross, Professor of Structures, Materials, and Fluids, University of South Florida, discusses mathematical models of flushing that can be used to estimate the build-up and removal of nutrients and pollutants in these bodies of water. It is interesting to note that as the tide leaves a bay, much of the dissolved material is carried out into and mixes with the waters of the Gulf--but the return tide carries much of the material back into the bay. In Tampa Bay, for example, the return tide carries back three-quarters of the dissolved substance. Thus, one-quarter of the inventory of dissolved material is flushed out by each tidal cycle.

Dr. H. K. Brooks, Professor of Geology, University of Florida, points out that the Gulf of Mexico and the adjoining land have received more attention from geologists than any other portion of the world. The Gulf basin is a mediterranean-type sea bounded by land masses containing rock rich in silica and alumina, and by the carbonate banks of the Florida-Bahama Platform and the Campeche-Yucatan Bank. A great mass of sediments with thickness exceeding 40,000 feet extends along the northern and western Gulf Coast. Much of this sedimentary mass is underlain by salt. Rather important to coastal residents and engineers is the observation that sea levels during the past several thousand years seem to have varied. Since 1870 there has been a worldwide sea-level rise of 8 to 10 inches; in the Eastern Gulf a rise of 3 to 4 inches occurred during the period 1930 to 1946. The rise has been slower since then. Because the coast is so flat, a rise of one foot may cause a shoreline regression of 100 feet. Tectonically, the Eastern Gulf is quite stable; no earthquakes have been reported. Because of this, the geological and environmental changes that have occurred in the Eastern Gulf in the last 15 to 20 million years have been due to changes in world climate and the glacial eustatic fluctuations in sea level. Changes have occurred and will continue to occur because of the dynamic nature of the biological and physical processes.

Dr. Harold J. Humm, Professor and Chairman, Department of Marine Sciences, University of South Florida, reports on the biological environment. Salt marshes are intertidal zone plant communities that develop along coasts of very low energy and of gradual slope. They may occupy a narrow fringe of the coastline or they may cover an area of a mile or more in width. Salt marsh vegetation of the Eastern Gulf consists predominantly of three grass species, one species of rush, and a few species of succulents. Salt marshes produce large quantities of organic matter. Some is stored in the form of peat, some is recycled through a variety of food chains, and some moves into the sea. The marshes are the habitat of a considerable number of birds and a large variety of invertebrate animals. They provide much protection to low-lying uplands adjacent to them, protecting the uplands from salt water intrusion, coastal erosion and destructive salt spray.

About 400 species of algae have been identified in the Gulf. Many of these species are limited in the Eastern Gulf because of a lack of rocky substrate on which to develop. Near Sarasota, Florida, a conglomerate of shell fragments and beach rock supports a flourishing algal flora. At other places, limestone outcrops form a good substrate. In many inshore areas, good development of benthic algae is found only on man-made structures such as jetties and seawalls. In these areas, the only natural substrates are oyster bars, scattered clam shells, prop roots of the red mangroves, and leaves of seagrasses. Most of the algae flourish in the light zone and where nutrients are rich. Grazing by fishes, crustacea, and mollusks is a significant factor in algal abundance, distribution, and form. The notorious red tide of the Eastern Gulf, known to be toxic to fish and invertebrates, is apparently toxic to benthic algae also. It was observed during the red tide of 1971 along the Florida West Coast that many fishes and invertebrates were killed and the larger benthic algae on the reef died, leaving the rocks bare.

Seagrasses are flowering plants that grow completely submerged in sea water. Five species grow abundantly on the continental shelf of the Eastern Gulf. These grasses trap sediments and stabilize the bottom. They serve as direct food sources for sea urchins, turtles, manatees, and some fishes; partially decomposed leaves serve as food for a variety of invertebrates and some fishes. The young of many species of fish and invertebrates find shelter in the seagrasses, and the grasses serve as habitat for invertebrates and algae.

Four species of mangroves are native to the shores of the Eastern Gulf. One, the black mangrove, is continuous along the coastline; centered in the area of the Ten Thousand Islands is one of the great mangrove forests of the Western Hemisphere. Because they grow in sea water and because of their aerial and prop roots, mangroves are land-builders as well as lowland protectors. Debris accumulates in their roots and forms peat. The mangrove stands are a habitat for many species of marine algae along with a host of both attached and free-living invertebrates. A variety of birds inhabit mangrove forests.

Phytoplankton, the drifting, minute plant life of the sea, are discussed by Ms. Karen A. Steidinger, Research Biologist, Department of Natural Resources, Marine Research Laboratory in St. Petersburg, Florida. Phytoplankton are distributed from the estuaries to the open Gulf. While their development and distribution vary seasonally, areas of upwelling and river drainage are most productive. One type of phytoplankton, *Gymnodium breve*, is the causative organism of the red tide; filter-feeding animals such as oysters and clams take in whole *G. breve* cells or the toxin and can accumulate the toxin. During red tides, shellfish beds are closed to harvesting and are reopened only after shellfish meat shows no sign of toxicity. No human deaths are known to have been caused by the toxin, although it causes some discomfort.

Zooplankton, the drifting or weakly swimming minute animal life of the sea, are discussed by Dr. Thomas L. Hopkins, Assistant Professor, Department of Marine Science, University of South Florida. Like phytoplankton, seasonal variations to zooplankton standing-crop and distribution are affected by land drainage and to some extent by annual variations in temperature. Upwelling generated by the Loop Current is responsible for the summer biomass maximum on the southwestern Florida shelf, while river discharge and cool conditions are primarily responsible for the winter peak on the northern Gulf shelf.

According to Dr. S. B. Collard, Assistant Professor of Marine Chemistry, University of West Florida, and Dr. C. N. D'Asaro, Associate Professor of Biology, University of West Florida, the distribution and limits of the benthic invertebrates are influenced near shore by temperature and salinity, but both near shore and offshore the greatest factor is substrate. The fauna reported include the sponges, corals, segmented worms, snails, bivalves (oysters, scallops, mussels, clams, etc.), crabs, shrimps, starfish, sea urchins, sea cucumbers, etc. Discharge of pollutants from man's activities onshore affect the benthic invertebrate communities. Sedimentation from dredging seriously affects oyster beds.

Marine mammals include the whales, dolphins, seals, sea lions, and manatees. In general, no whales and only two species of dolphins are of commercial importance in the Eastern Gulf. Dr. David K. Caldwell, Associate Professor and Head, Communication Sciences Laboratory, Division of Biocommunication, University of Florida, and Ms. Melba C. Caldwell, Research Associate of this same institution, point out that marine mammals are now under legal protection in the Eastern Gulf and that the effects of land and resource development need to be studied. At present, the greatest danger to the mammals seems to come not from development but from poaching and fishing. Many species of cetaceans (whales, porpoises) are carnivores. The manatees are vegetarians, and the pinnipeds (seals and sea lions) are fish eaters. The young of cetaceans are born alive after a gestation period of 12 to 16 months. The young are protected by the mother and the herd; they are suckled for about a year. Dolphins reach an age of about 30; whales somewhat older.

A list of 81 species of birds common along the Eastern Gulf is presented by Dr. Glen E. Woolfenden, Professor of Zoology, and Mr. Ralph A. Schreiber, both in the Department of Biology, University of South Florida. Of these species, 73 are either permanent or winter residents. The population of most species seems to be rather stable, except for brown pelicans, eagles, and ospreys. It is thought that destruction of habitat is most harmful to the eagles and ospreys, although pesticides and egg infertility have been demonstrated. The brown pelican, the state bird of Louisiana, has largely disappeared from the Louisiana and Texas coasts--the last known wild brown pelican nesting in Louisiana was in 1961. Shell-thinning caused by DDT residue is the cause. In Florida, the total brown pelican population is estimated at 25,000 to 30,000, and it appears to have been stable over the past five years. DDT contamination and shell-thinning have been observed, but egg loss does not seem to have affected the population. The brown pelican is dependent on the mangrove stands for nesting grounds.

The section on fisheries resources is authored by Dr. John L. Taylor, Consulting Marine Ecologist, St. Petersburg Beach, Florida; Mr. David L. Feigenbaum, Director of Fisheries and Applied Estuarine Ecology, Rosenstiel School of Marine and Atmospheric Science, University of Miami; and Ms. Mary Lou Stursa, Information Coordinator, Florida Coastal Coordinating Council, Florida Department of Natural Resources. In terms of fishery production and value, the waters of the Gulf of Mexico are second only to those of the Peruvian Coast. High fishery production in the Gulf is related to availability of vast quantities of nutrient materials supplied by the Mississippi River and other tributaries, from ocean upwelling along shore, and from decomposition of marshland and submerged vegetation. Currently, the Gulf catch is about 1.7 billion pounds with a market value of more than $165 million annually. Of the 70 or more species taken by Gulf commercial fisheries, the five leading ones by volume are menhaden, shrimp, blue crab, mullet, and oyster. Inshore sport fish species include seatrout, drum, tarpon, Spanish mackerel, and pompano. Offshore favorites are marlin, swordfish, sailfish, albacore, tuna, dolphin, and king mackerel. Estimates are that the Gulf sport fishing take is 1/3 to 1/2 the commercial catch, and the money spent by sport fishermen probably equals or exceeds the value of the commercial landings. Although the Gulf is the highest U. S. producing region, indications are that many stocks are under-utilized. Not utilized are butterfish, harvestfish, bumpers, scad, and jacks, which occur in dense concentrations. Catches of bottom fish can be greatly increased. Anchovies and thread herring seem to be abundant, but no commercial method of catching them has been developed. Foreign fishing and pollution dim the outlook for Gulf fisheries. The USSR, Cuba, and Japan have shown interest in Gulf fishing; sport fishing groups have come to some agreement with Japanese long-line fishing vessels that take large quantities of the bigger sport fish. Federal, state, and private programs are being directed to aquaculture of high-yield, high-priced species such as oyster, shrimp, spiny lobster, and pompano. The entire coastal wetland ecosystem--barrier beaches, tidal flats, mangrove areas, saltwater marshes, freshwater marshes, and the sea itself--all interact to provide wildlife with the essential elements required to live and thrive. How much is an acre of Gulf Coast wetland worth? Estimates suggest that fish production alone on an acre of wetland has an annual monetary value of anywhere from $200 to $500.

Ms. Stursa also presents an overview of recreation and industry. In Florida alone, over 23 million tourists come to the state each year. An estimated 75 per cent are attracted by the beach and saltwater activities. Florida tourism is estimated to be a four-billion-dollars-a-year business. In Alabama, the coast has been developed mostly for summer retreat activities rather than tourism. In Mississippi, the 27-mile-long man-made "Gold-Coast" beach has long been very popular, but much of it was damaged by Hurricane Camille. Food processing is the single largest industry on the Gulf Coast. Several large paper mills are located where the quantities of fresh water needed are available. Chemical plants produce acrylic fibers, fertilizers, ammonia, nitric acid, and paints. Although citrus is the major money crop of Florida, vegetables and cattle are important products. Important phosphate mines are located near Tampa Bay. Tampa Harbor is Florida's busiest port. Inland channels and the Intracoastal Canal carry a heavy tonnage of commerce. Planning and management of the coastal zone of the Eastern Gulf region are needed in order to provide both public recreational facilities and economic welfare, while protecting the unique qualities of the natural environment. Land use and shoreline priorities need to be established.

Environmental quality problems are another topic covered by Ms. Stursa. She points out that hurricane force winds have caused extensive damage to mobile homes and vacation cottages, to structures such as radio towers, and to telephone lines. Floods produced by hurricane rainfall are more damaging than winds. A typical hurricane can bring up to 12 inches of rainfall to the area it crosses. But the worst effect of a hurricane comes from the sea. As a storm crosses the continental shelf and moves coastward, mean water level may increase 15 feet or more; Hurricane Camille produced tides of almost 25 feet above mean sea level in Mississippi. The advancing storm surge is superimposed on normal tides, and wind waves are superimposed on the surge. Because so much of the Gulf Coast lies less than 10 feet above mean water level, the danger from storm surges is great. Wave and current action associated with a storm surge collapse buildings and erode beaches. One bizarre incident occurred during Hurricane Agnes in 1972, when intruding salt water drove snakes from freshwater marshes inland. "Snake warnings" were issued along with the storm warnings.

Artificial, or man-made, damage is having an impact on the Eastern Gulf. Estuarine and bay areas are being lost to landfill operations. In Florida, estimates are that more than 59,000 acres of estuarine habitat have been lost to dredging and 23,000 acres to housing, industry, and other development out of an original 796,000 acres. Dredging affects seagrasses and marine life associated with them; in some areas, the seagrasses redeveloped rapidly after operations ceased. In Alabama, much of the marsh area around Mobile has been filled for development. Extensive dredging has been done in Mobile Bay to maintain boat and ship channels; this has caused extreme siltation and damage to oyster production. Pollution coexists with large communities and concentrations of industry along the Eastern Gulf. Some estimates indicate that polluted areas make up 31 per cent of the area of all West Coast estuaries. Few studies have been done on pesticides, polychlorinated biphenyls (PCB), other chlorinated compounds, heavy metals, and radio-nuclides.

This volume was edited by Dr. James I. Jones, Associate Professor of Geological Oceanography, Florida State University; Mr. Ronald E. Ring, Manager, Market Planning and Sales Support, Martin Marietta Aerospace, Orlando Division; Mr. Murice O. Rinkel, Assistant Director, State University System of Florida, Institute of Oceanography; and Dr. Robert E. Smith, Director, State University System of Florida, Institute of Oceanography. The Florida Coastal Coordinating Council, Florida Department of Natural Resources; the Marine Research Laboratory, Florida Department of Natural Resources; and the Martin Marietta Aerospace, Orlando Division, cooperated in this work.

Preparation of this report was supported by a grant from the American Petroleum Institute through its Subcommittee on Fish, Wildlife, and Conservation of the Environmental Task Force, Committee on Exploration.

APPENDICES

Appendix I

STATE UNIVERSITY SYSTEM OF FLORIDA
INSTITUTE OF OCEANOGRAPHY
830 First Street, South, St. Petersburg, Florida 33701
Phone (813) 896-5197

December 13, 1973

TO: Active or Potential Participants and Other Concerned Parties

SUBJECT: Oceanographic and associated data and information needs preparatory to exploration and production of petroleum from the eastern Gulf of Mexico; proposed conference and workshop to address same

THE FINAL ENVIRONMENTAL STATEMENT For a Proposed 1973 OUTER CONTINENTAL SHELF OIL AND GAS GENERAL LEASE SALE OFFSHORE MISSISSIPPI, ALABAMA, AND FLORIDA; OCS SALE NO. 32 FES 73-60; Volumes 1 - 5; Prepared by the BUREAU OF LAND MANAGEMENT, U.S. DEPARTMENT OF THE INTERIOR has been published (draft statement made available to Council on Environmental Quality and the public on July 16, 1973). The drafts of this environmental statement have been critiqued by a cross section of individuals and groups representative of federal and state agencies of academia and industry; copies of critiques have been incorporated as part of the afore-cited final statement.

It is not a purpose of this memorandum to attempt to present any type of synopsis or review of this environmental statement per se; but it is a purpose of this memorandum to review one particular aspect of it. The concensus of opinion of a substantial number of persons who have had opportunities to study the report, and as has been reflected in many of the critiques published therein, is that the data base from which the statement was prepared was inadequate for that purpose. The critics conclude that there are not sufficient data and/or information currently available that would enable one to adequately answer the variety of environment related questions that should be asked about the eastern Gulf of Mexico prior to the proposed oil exploitation. In some relevant data areas it appears that there is virtually a total absence of data; in other cases, there are existing published data much of which have not been processed into a usable and/or compatible form, whereas in still other cases data have been collected but are either unprocessed, privileged and/or proprietary, yet in any case are not available for critical assessment and/or public evaluation.

As active or potential participants of the research community of the eastern Gulf, and other concerned parties, we are aware that during the past several

University of Florida Gainesville · *Florida State University Tallahassee* · *Florida A. & M. University Tallahassee* · *University of South Florida Tampa* · *Florida Atlantic University Boca Raton*
University of West Florida Pensacola · *Florida Technological University Orlando* · *University of North Florida Jacksonville* · *Florida International University Miami*

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years there have been accelerating research activities in this particular area. Much of this research has been conducted as multi-ship, near-synoptic data gathering and sampling operations of time-series types, and of interdisciplinary nature. Government, academia, and industry, all are playing active roles, and their respective personnel have performed a tremendous amount of work in the joint planning and conducting of same. As a result an extremely large number of collections have been performed in a coordinated manner. Appropriate documentation, standardization, data verification, etc., have been designed into the programs and the results are inventoried accordingly.

The point is, we would probably all agree that there are more data needed to enable one to prepare proper environmental impact statements of the eastern Gulf of Mexico as pertains to the proposed oil exploitation of the area, but we would probably also hasten to stress the fact that a substantial amount of the sampling performed during the past several years in this area is still being sorted and identified and data being processed and as a consequence have not been reported, thus being made available to others for their consideration and use.

A representative cross section of past and ongoing work in the eastern Gulf relative to the subject is: EASTERN GULF OF MEXICO (EGMEX) Program; HOURGLASS Cruises; WESTERN FLORIDA CONTINENTAL SHELF Program; AN OCEANOGRAPHIC SURVEY OF THE FLORIDA TERRITORIAL SEA OF NORTHWEST FLORIDA (ESCAROSA); FLORIDA MIDDLE GROUND TIME-SERIES DIVING Program; SCIENTIST-IN-THE-SEA (SITS Program); GULF OF MEXICO ESTUARINE INVENTORY (GMEI) Program; several manned and unmanned submersible studies; and numerous investigators conducting their individual projects yet not necessarily coordinated as a finite part of any one major program per se. Numbers of theses, dissertations, articles in periodicals and reports of various types are coming out as a result of these, but it is apparent that more time and certainly funding support are required before the remaining portions of the work can be made available to others.

To briefly outline some of the perceived information needs that have been stated by critics of the final environmental statement of the eastern Gulf, needs that should be addressed in order to enable one to better understand and appreciate this particular area, the following are presented for consideration.

1. Shallow shelf sediments: Evaluation of basic lithology, physical properties, existence and extent of shallow subsurface hazards to drilling platforms or pipeline placement (e.g. newly discovered karst zone off Clearwater/Tarpon Springs) and between lease areas and proposed port or terminal facilities, distribution of dumped debris, munitions, heavy metals (polluted sediments), and hydrocarbons (see item 2).

2. Hydrocarbon distribution: Work in recent years has permitted identification ("fingerprinting") of petroleum products by sophisticated geochemical techniques. With appropriate background studies in local areas, it is possible to distinguish between natural hydrocarbons that are present in greater or lesser

trace quantities in all sediments, and crude oil or other pollutants, and even to distinguish crudes or refined products of varying type, and interpret approximate length of time exposed to degradation on the sea floor. In the northern Gulf of Mexico, lengthy litigation about alleged damage to oyster beds by crude oil spills was complicated by lack of proper baseline data prior to the specific spills and prior to oil production operations in general. Such studies ought to be regarded as essential background information in any potentially productive petroleum province, and should be performed on sediment cores from the West Florida Shelf in general, and the proposed leasing tracts in particular.

A special kind of hydrocarbon survey ("sniffer") involves detection and measurement of light hydrocarbons in bottom water from a ship underway. Such studies can rapidly map distribution of hydrocarbons emanating from the sea floor, or existing in the water column. Oil companies have used these studies to delineate submarine oil and gas seeps (major and micro), whereas the few published (academic) studies have chiefly pinpointed pollution sites. It is proposed that such surveys be carried out on both state and federal offshore lands that are potentially productive of petroleum, and be made public. Such data would not only have a bearing on the existence of petroleum reservoirs at depth in some cases, but would yield information on zones of fracturing or other rock weakness, leading to upward leakage of fluid and gases. It is fortunate that several groups with the necessary experience and skills have indicated a tentative willingness to undertake pertinent studies of this type on the West Florida Shelf.

3. Deeper structural geologic studies: A limited number of seismic traverses are available in the West Florida Shelf area, in the form of published papers. To these may be added some deeply penetrating but privileged seismic profiles purchased by the Conservation Division of the U. S. Geological Survey. Like private oil company data, these profiles and interpretations based on them are not available to the scientific community in general or the public at large, and therefore neither the factual base nor the detailed conclusions have been exposed to the usual competitive scientific scrutiny and testing in the open literature. It is believed that problems of practical interest to people of the State of Florida and surrounding states should be illuminated by investigation and open publication of the results.

4. Current patterns and sediment transport: The meteorological phenomena and patterns of water and bottom sediment movements should be better understood and appreciated in the West Florida Shelf area. These phenomena must be determined both for short term and by season, and, insofar as can be appraised statistically, for hurricane and storm occurrences. Such information would be valuable for many purposes, and is pertinent for predicting possible effects of oil exploitation in the area.

5. Flora and fauna: The spatial and temporal relationships of plant and animal life on and within the sediments of the shelf should be determined and correlated to fish and other populations in the vertical water column. Such

inventories should be accompanied by study of key ecological parameters and relationships. As in previous cases, whereas baseline of information should be available before extensive activities on the shelf commence, the studies ought not be limited to mere inventories, but should be accompanied by in-depth study of key ecological parameters and relationships conducted on time-series basis.

6. Baseline chemical investigations: Since it is reasonable to anticipate some chemical changes both in the water column and sediment, relative to the exploration and production operations, it is imperative to precisely characterize a variety of chemical parameters prior to the introduction of "exotic" chemicals coincident with the offshore operation.

The main purpose of this memorandum is to propose a conference and workshop to discuss the state of knowledge on and informational needs for the eastern Gulf, ways in which we may be mutually helpful, and proposed plans of action. The conference should include scientific and technical sessions exploring various aspects of the problems, including political-legal aspects and to conclude with a workshop to develop plans for implementing cooperative programs as soon as possible. Representatives of funding agencies should be invited to outline criteria for support and provide advice in fashioning viable programs.

The date of the proposed meeting is recommended to be January 31 to February 2, 1974, and the site to be St. Petersburg, Florida. Funds are being sought to provide assistance to a limited number of participants who might otherwise have difficulty in attending.

It is with regret that such an important meeting as proposed is being set up on such short notice, but the rapidity with which developments are occurring and the urgency of the problem make delay inadvisable.

Many persons are either performing studies in the eastern Gulf area at present, or have indicated that they want to do so. It appears that a coordinated, cooperative effort could serve to: speed results; maximize effectiveness of utilization of shiptime and associated expensive equipment and manpower; promote cost effectiveness; and further foster fruitful interaction among individuals, oranizations, and disciplines. This consortium concept certainly is nothing new, but a broader cross section of representatives of federal and state agencies, public and private universities, and industries has become involved during the past weeks than has been the case previously.

To avoid inadvertently failing to cite all individuals and their respective organizations that have "inspired" the preparation of this memorandum, suffice it to say, there are many. In order to identify a couple of persons who can be contacted for realtime and/or more detailed information the following are listed:

Dr. James I. Jones, Research Coordinator
Florida Coastal Coordinating Council
309 Magnolia Office Plaza
Tallahassee, Florida 32306
Telephone: 904/488-8614

Dr. Frank T. Manheim, Director
Department of Marine Science
University of South Florida
830 1st Street So.
St. Petersburg, Florida 33701
Telephone: 904/898-7411

Drs. Jones and Manheim were appointed earlier this week to an inter-agency committee in Washington, D. C., to participate in the planning of the proposed eastern Gulf activities; oil exploration in general, but the research needs in particular.

The floor is open for responses to the subject of this memorandum; look forward to working up a program for the proposed conference and workshop and a mailing list for same with you.

Robert E. Smith
Director

RES/ah/rvf

Appendix II

Florida Interinstitutional Committee on Oceanography

Dr. Robert E. Smith, Chairman
Director, State University
System of Florida Institute
of Oceanography
830 First Street South
St. Petersburg, Florida 33701

Dr. Alfred B. Chaet
Provost, Gamma College
University of West Florida
Pensacola, Florida 32504

Dr. Sheldon Dobkin, Chairman
Department of Biological Science
Florida Atlantic University
Boca Raton, Florida 33432

Dr. Leslie L. Ellis, Jr., Dean
Graduate Studies and Research
Florida Technological University
P. O. Box 25000
Orlando, Florida 32816

Dr. Ernest A. Hogge, Head
Scientific Support Division
Naval Coastal Systems Laboratory
Panama City, Florida 32401

Dr. Robert M. Johnson, Provost
Graduate Studies and Research
Florida State University
Tallahassee, Florida 32306

Dr. William B. Phillips, Director
Science and Engineering
State University System of Fla.
107 W. Gaines Street
Tallahassee, Florida 32304

Dr. Hugh L. Popenoe, Director
Center for Aquatic Sciences
2001 McCarty Hall
University of Florida
Gainesville, Florida 32601

Dr. William S. Richardson, Director
Oceanographic Center
Nova University
8000 N. Ocean Drive
Dania, Florida 33004

Dr. Abraham Stein, Chairman
Biological Sciences Department
Florida International University
Tamiami Trail
Miami, Florida 33144

Dr. Chebium B. Subrahmanyam
Assistant Professor
Department of Biology
Florida A&M University
Tallahassee, Florida 32307

Dr. William H. Taft
Director of Sponsored Research
University of South Florida
Tampa, Florida 33620

Dr. Allan Tucker
Vice Chancellor for Academic Affairs
State University System of Florida
107 W. Gaines Street
Tallahassee, Florida 32304

Rear Admiral O. D. Waters (Ret.) Head
Head Department of Oceanography
Florida Institute of Technology
P. O. Box 1150
Melbourne, Florida 32902

Dr. Warren S. Wooster, Dean
University of Miami
Rosenstiel School of Marine
and Atmospheric Science
10 Rickenbacker Causeway
Miami, Florida 33149

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Appendix III

STATE UNIVERSITY SYSTEM OF FLORIDA
INSTITUTE OF OCEANOGRAPHY
830 First Street, South, St. Petersburg, Florida 33701
Phone (813) 896-5197

ANNOUNCEMENT/INVITATION

CONFERENCE/WORKSHOP

MARINE ENVIRONMENTAL IMPLICATIONS OF OFFSHORE DRILLING IN THE EASTERN GULF OF MEXICO

31 January, 1, 2 February 1974
University of South Florida, St. Petersburg Campus
830 First Street South, St. Petersburg, Florida

The impending Outer Continental Shelf (OCS) oil exploration and production activities in the eastern Gulf of Mexico have catalyzed the interest and concern of a most significant cross section of individuals and organizations. The Conference/Workshop is to be held to properly define by priority the critical research and/or information needs in the subject area, to develop a scientifically sound and relevant interdisciplinary program and to identify the persons to implement same.

Many formalities have been dispensed with due to the limited time frame in which to complete the preparation of the program. Consequently, we ask that you accept this communication as an invitation to attend and to participate in the deliberations. Please share this information and invitation with other interested and/or concerned persons.

For additional information, please contact the State University System of Florida Institute of Oceanography (SUSIO) AC 813/896-5197.

There will be no registration fees, however we would appreciate receiving from you, as soon as possible, information as to whether or not you plan to attend. Please use the enclosed self-addressed card for expedience in furnishing us the information that will enable us to have adequate conference and workshop space to accommodate all participants.

Enc.

1/15/74

University of Florida Gainesville . *Florida State University Tallahassee* . *Florida A. & M. University Tallahassee* . *University of South Florida Tampa* . *Florida Atlantic University Boca Raton*
University of West Florida Pensacola . *Florida Technological University Orlando* . *University of North Florida Jacksonville* . *Florida International University Miami*

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Appendix IV

MARINE ENVIRONMENTAL IMPLICATIONS OF OFFSHORE DRILLING
IN THE
EASTERN GULF OF MEXICO

CONFERENCE/WORKSHOPS

January 31, February 1, 2, 1974

Supported by

State University System of Florida
Bureau of Land Management
Environmental Protection Agency
American Petroleum Institute
State University System of Florida Sea Grant Program

Hosted by

University of South Florida
Department of Marine Science
St. Petersburg Campus, Bayboro Harbor
St. Petersburg, Florida

and

Florida Department of Natural Resources
Marine Research Laboratory
St. Petersburg, Florida

Coordinated and Administered
through

State University System of Florida Institute of Oceanography (SUSIO)
St. Petersburg, Florida

Florida Coastal Coordinating Council (FCCC)
Tallahassee, Florida

Florida Interinstitutional Committee on Oceanography (FICO)

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January 31, 1974

CONFERENCE

Auditorium

0845 Introductory Remarks; Objectives of Conference and Workshops - Dr. Robert E. Smith, SUSIO

0900 Bureau of Land Management Responsibilities and Goals as Pertains to the Eastern Gulf of Mexico - Mr. John Sprague, BLM

0925 Environmental Protection Agency's Role, Interests and Responsibilities With Respect to the Outer Continental Shelf Development - Dr. Andrew McErlean, EPA

0940 Coffee Break

0955 Geological Survey's Contributions to Ecosystems Research - Dr. Roland von Huene, USGS

1010 NOAA's Role and Responsibilities With Respect to Outer Continental Shelf Development in the Eastern Gulf of Mexico - Dr. Allan Hirsch, NOAA

1030 The U. S. Navy's Oceanography Program; Offshore Technology - CDR Larry M. Riley, Oceanographer of the Navy Office

1045 Florida Coastal Zone Environmental Considerations as Related to Petroleum Exploitation in the Eastern Gulf of Mexico - Dr. James I. Jones, FCCC

1105 Legal Aspects of Resource Exploration and Exploitation in the Eastern Gulf of Mexico - Mr. Dennis M. O'Connor, U M

1130 An Overview of the Petroleum Industries Marine Environmental Research - Mr. Edward W. Mertens, Chevron Research Company

1155 Lunch

After lunch presentation: The Florida Middle Ground (35 mm color slide presentation on the bottom topography, geological outcrops and associated biological communities as recorded by diving scientists) - Dr. Thomas S. Hopkins, UWF: Mr. Larry H. Ogren, NMFS/P.C. and Mr. Gregory B. Smith, DNR/MRL

January 31, 1974
contd.

Assessment of Marine Environment of the Eastern Gulf of Mexico State of Knowledge and Information Needs

1330 Physical Oceanography - Chairman: Dr. William S. Richardson, Nova U.

An Introduction to the Physical Oceanography and Meteorology of the Gulf of Mexico - Dr. William S. Richardson

The Loop Current Regime - Mr. George A. Maul, NOAA/AOML

Wind-Driven Currents on the West Florida Shelf - Dr. Wilton B. Sturges, FSU and Mr. John Cragg, FSU

The Temperature Field on the West Florida Shelf - Mr. Murice O. Rinkel, SUSIO

Tidal Currents on the West Florida Shelf - Dr. Harold Mofjeld, NOAA/AOML

Response of the West Florida Shelf Circulation to Strong Meteorological Forcing - Dr. Christopher N. K. Mooers, U M

1530 Biological Oceanography - Chairman: Dr. Robert E. Smith, SUSIO

Algaes, Seagrasses and Mangroves - Dr. Sylvia Earle Mead, LACM; Dr. Harold J. Humm, USF; Dr. K. M. S. Aziz, USF

Benthic Invertebrates - Dr. Sneed B. Collard, UWF; Dr. Charles N. D'Asaro, UWF; Mr. William Lyons, DNR/MRL

Phyto and Zooplankton - Dr. Thomas L. Hopkins, USF; Dr. Sayed Z. el-Sayed, TAMU; Miss Karen Steidinger, DNR/MRL

Coffee

Bioindicators - Dr. Herbert M. Austin, NYOSL

Fish Eggs and Larvae - Dr. Edward D. Houde, RSMAS/U M

Fisheries Resources, Recreational and Commercial - Mr. Harvey R. Bullis, NOAA/NMFS/SFC

1830

No organized dinner or evening activities scheduled.

1 February 1974

(scientific sessions contd.)

0800 Chemical Oceanography - Chairman: Dr. John A. Calder, FSU

Inorganic Aspects of OCS Petroleum Operations - Dr. Eugene F. Corcoran, RSMAS/U M

Significance of Low Molecular Weight Hydrocarbons in Eastern Gulf Waters - Dr. William Sackett, TAMU

Problems Associated With the Collection of Environmental Samples for Hydrocarbon Analysis - Dr. John Farrington, WHOI

Problems of Experimental Design for Hydrocarbon Detection in an Oil Producing Region - Dr. Patrick L. Parker, UTMSI

Coffee

1000 Geological Oceanography - Chairman: Dr. Frank T. Manheim, USF

Structural Framework of the West Florida Continental Shelf - Dr. Thomas E. Pyle, USF; Dr. W. R. Bryant, TAMU; Mr. J. W. Antoine, TAMU

General and Geotechnical Aspects of Surficial Deposits on the West Florida Shelf - Dr. H. K. Brooks, U F

Sediment Transport in the Nearshore Zone - Dr. W. F. Tanner, FSU

1200 Summary of Scientific Presentations: Set the stage for the transition from the scientific sessions to the workshops - Dr. William S. Richardson

1215 Data and Information; Sensor to Center - Mr. Robert V. Ochinero, NOAA/EDS/NODC

1230 Lunch - Open so that individuals can have lunch with their colleagues for small group discussions.

Concurrent Workshops

Planning, with appropriate priorities, for cooperative investigations relevant to the environmental effects of petroleum exploration and production in the eastern Gulf of Mexico.

1345 Physical Oceanography - Moderator: Dr. William S. Richardson
(Room 223A-2nd floor) Rapporteur: Dr. John Cochrane, TAMU

February 1, 1974
(Concurrent Workshops contd.)

Biological Oceanography - Moderator: Dr. Frank Williams, RSMAS/U M
(DNR Conference Room Building C) Rapporteur: Mr. Eugene L. Nakamura, NOAA/EGML/NMFS

Geological and Chemical Oceanography - Co-Moderator: Dr. James I. Jones
(Room 223B-2nd floor) Co-Moderator: Dr. James Alexander, NYOSL
Rapporteur: Dr. Peter R. Betzer, USF

1730

1830 Smoked Fish and Beer - Auditorium

February 2, 1974

0800 Continuation of workshops; restructuring if determined by moderator to be appropriate.

1200 Lunch - Open

1330 Reports by moderators on results of workshop sessions
Chairman: Dr. Harris B. Stewart, Jr., NOAA/AOML

Open Discussion

1600 Adjourn

Appendix V

MARINE ENVIRONMENTAL IMPLICATIONS OF OFFSHORE DRILLING IN THE EASTERN GULF OF MEXICO

January 31, February 1, 2, 1974
University of South Florida, St. Petersburg Campus
830 First Street South, St. Petersburg, Florida 33701

ROSTER

Mr. J. Kenneth Adams
University of West Florida
3429 Wellington Road
Pensacola, Florida 32504

Dr. James E. Alexander
New York Ocean Science Laboratory
Drawer EE
Montauk, New York 11954

Dr. Jack W. Anderson
Biology Department
Texas A&M University
College Station, Texas 77843

Miss Kip Anthony
Florida State University
Tallahassee, Florida 32306

Mr. John Antoine
Texas A & M University
Department of Oceanography
College Station, Texas 88943

Dr. Herbert Austin
New York Ocean Science Laboratory
Drawer EE
Montauk, New York 11954

Dr. R. C. Baird
Department of Marine Science
University of South Florida
830 First Street South
St. Petersburg, Florida 33701

Dr. H. D. Baldridge
Mote Marine Laboratory
9501 Blind Pass Road
Sarasota, Florida 33581

Dr. David Banner
Bayshore Systems Corporation
5406A Royal Road
Springfield, Virginia 22151

Ms. Christy Barbee
WUSF News
University of South Florida
Tampa, Florida 33620

Mr. Dale S. Beaumariage
Florida Department of Natural Res.
Marine Research Laboratory
100 Eighth Avenue S.E.
St. Petersburg, Florida 33701

Mr. Paul Behrens
University of South Florida
830 First Street South
St. Petersburg, Florida 33701

Dr. Fred Bell
Economics Department
Florida State University
Tallahassee, Florida 32306

Mr. Homer Benton
Bureau of Land Management
3200 Plaza Towers
New Orleans, Louisiana 70062

Mr. Terry Bengtsson
800 First Street S.
St. Petersburg, Florida 33701

Mr. Carroll D. Bernier
State University System of Florida
Institute of Oceanography
830 First Street South
St. Petersburg, Florida 33701

Dr. Peter R. Betzer
Department of Marine Science
University of South Florida
830 First Street South
St. Petersburg, Florida 33701

Dr. Susan B. Betzer
Department of Marine Science
University of South Florida
830 First Street South
St. Petersburg, Florida 33701

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Mr. T. W. Bilhorn
G.U.R.C.
10 Rickenbacker Causeway
Miami, Florida 33149

Dr. Norman Blake
Department of Marine Science
University of South Florida
830 First Street South
St. Petersburg, Florida 33701

Mr. A. W. Blizzard
Department of Biology
University of West Florida
Pensacola, Florida 32504

Mr. Earl Blomeley
Standard Oil Company
406 Reo Street
Tampa, Florida 33609

Dr. Stephan Bortone
Department of Biology
University of West Florida
Pensacola, Florida 32504

Mr. Millar Brainard, Jr.
Continental Shelf Associates, Inc.
1221 Peppertree Drive
Sarasota, Florida 33581

Mr. R. S. Braman
Department of Chemistry
University of South Florida
Tampa, Florida 33620

Mr. John A. Braswell
Naval Coastal Systems Laboratory
Code 773
Panama City, Florida 32401

Dr. John C. Briggs
Director of Graduate Studies
University of South Florida
Tampa, Florida 33620

Dr. Thomas J. Bright
Department of Oceanography
Texas A&M University
College Station, Texas 77843

Dr. H. K. Brooks
Department of Geology
University of Florida
Gainesville, Florida 32601

Mr. Curtis Broussard
Crest Engineering, Inc.
P.O. Box 6127
New Orleans, Louisiana 70174

Dr. John Brown
Department of Geology
Florida State University
Tallahassee, Florida 32306

Mr. Gerard Bruger
Florida Department of Natural Res.
Marine Research Laboratory
100 Eighth Avenue S.E.
St. Petersburg, Florida 33701

Dr. William Bryant
Department of Oceanography
Texas A&M University
College Station, Texas 77843

Mr. Harvey R. Bullis
NOAA/NMFS
Southeast Fisheries Center
75 Virginia Beach Drive
Miami, Florida 33149

Mr. Allen G. Burdette, Jr.
Department of Natural Resources
525 Mirror Lake Drive
St. Petersburg, Florida 33701

Dr. Nelson K. Butler
Leisure Studies Program
University of South Florida
Tampa, Florida 33620

Mr. Hal H. Bybee
Continental Oil Company
P.O. Box 2197
Houston, Texas 77001

Dr. John Calder
Department of Oceanography
Florida State University
Tallahassee, Florida 32306

Dr. David K. Caldwell
Biocommunications Laboratory
University of Florida
Route 1, Box 122
St. Augustine, Florida 32084

Dr. George Crozier
Dauphin Island Sea Lab
University of Alabama
Dauphin Island, Alabama 36528

Dr. John Caldwell
University of Florida
Marine Laboratory
1 Flint Hall
Gainesville, Florida 32611

Mrs. Melba C. Caldwell
Biocommunications Laboratory
University of Florida
Route 1, Box 122
St. Augustine, Florida 32084

Mr. David K. Camp
Florida Department of Natural Res.
Marine Research Laboratory
100 Eighth Avenue S.E.
St. Petersburg, Florida 33701

Ms. Bobbi Campbell
USF News Bureau
University of South Florida
Tampa, Florida 33620

Mr. W. G. Campbell
General Oceanics
5535 N.W. 7th Avenue
Miami, Florida 33127

Mr. Richard V. Cano
University of South Florida
Department of Marine Science
830 First Street South
St. Petersburg, Florida 33701

Dr. K. L. Carder
Department of Marine Science
University of South Florida
830 First Street South
St. Petersburg, Florida 33701

Mr. Jedfrey M. Carlton
Florida Department of Natural Res.
Marine Research Laboratory
100 Eighth Avenue S.E.
St. Petersburg, Florida 33701

Dr. J. H. Carpenter
Rosenstiel School
University of Miami
10 Rickenbacker Causeway
Miami, Florida 33149

Mr. H. H. Castleberry
Tenneco Oil Company
P.O. Box 51345
Lafayette, Louisiana 70501

Mr. M. Chaiffetz
Department of Geology
Florida State University
Tallahassee, Florida 32306

Dr. Y. Y. Chao
Dames & Moore
14 Commerce Drive
Cranford, New Jersey 07016

Mr. Donald P. Cheney
Department of Biology
University of South Florida
Tampa, Florida 33620

Mr. Wen-An-Chiou
Department of Marine Science
University of South Florida
St. Petersburg, Florida 33701

Mr. Lynn B. Clarke
Rosenstiel School
University of Miami
10 Rickenbacker Causeway
Miami, Florida 33149

Mr. Richard S. Clingan
Department of Marine Science
University of South Florida
St. Petersburg, Florida 33701

Mr. John J. Clopine
Florida Department of Natural Res.
Marine Research Laboratory
100 Eighth Avenue S.E.
St. Petersburg, Florida 33701

Mr. W. R. Cobb
Shell Oil Company
One Shell Square
New Orleans, Louisiana 70433

Mr. Craig P. Cochrane
Environmental Committee
706 Pinellas Point Drive South
St. Petersburg, Florida 33705

Dr. John C. Cochrane
Department of Oceanography
Texas A&M University
College Station, Texas 77843

Mr. Wilburn Cockrell
Florida Department of State
Capitol Building
Tallahassee, Florida 32301

Dr. Sneed B. Collard
Department of Biology
University of West Florida
Pensacola, Florida 32504

Mr. Christopher L. Combs
State University System of Florida
Institute of Oceanography
830 First Street South
St. Petersburg, Florida 33701

Dr. Eugene F. Corcoran
Rosenstiel School
University of Miami
10 Rickenbacker Causeway
Miami, Florida 33149

Dr. Geraldine Cox
Ratheon Company
P.O. Box 360
Portsmouth, Rhode Island 02871

Mr. John Cragg
Department of Oceanography
Florida State University
Tallahassee, Florida 32306

Ms. Jeanne Crampton
League of Women Voters
1624 Jefford
Clearwater, Florida 33516

Mr. Jim Crane
Florida Department of Natural Res.
Marine Research Laboratory
100 Eighth Avenue S.E.
St. Petersburg, Florida 33701

Lt. Vivien Crea
U. S. Coast Guard
Headquarters
Washington, D.C. 20591

Mr. Thomas J. Culpepper
Rader & Associates, Inc.
2075 Biscayne Blvd.
Miami, Florida 33137

Mr. Joe W. Daughtrey
Gulf Oil Company
P.O. Box 61590
New Orleans, Louisiana 70161

Ms. Joan Davenport
U. S. Environmental Protection Agency
Waterside Mall, S.W. (3211)
Washington, D.C. 20460

Mr. Richard A. Davis, Jr.
Department of Geology
University of South Florida
Tampa, Florida 33620

Dr. William Davis
Ecosystems Division
U. S. Environmental Protection Agency
Washington, D. C. 20460

Dr. Clinton Dawes
Department of Biology
University of South Florida
Tampa, Florida 33620

Mr. R. A. Dietz
Department of Marine Science
University of South Florida
830 First Street South
St. Petersburg, Florida 33701

Dr. Larry J. Doyle
Department of Marine Science
University of South Florida
830 First Street South
St. Petersburg, Florida 33701

Dr. Pieter S. Dubbelday
Florida Institute of Technology
Country Club Road
Melbourne, Florida 32901

Mr. Ted Duncan, Jr.
Florida Petroleum Council
111 Gadsden Street
Tallahassee, Florida 32301

Mr. J. Linwood Durrett
AMOCO Production Company
1040 St. Charles Avenue
New Orleans, Louisiana

Mr. Lee Edmiston
Department of Oceanography
Florida State University
Tallahassee, Florida 32306

Mr. Robert Eganhouse
Department of Oceanography
Florida State University
Tallahassee, Florida 32306

Mr. James D. Eger
Department of Geology
University of Florida
Gainesville, Florida 32601

Mr. Donald W. Eggimann
Department of Marine Science
University of South Florida
830 First Street South
St. Petersburg, Florida 33701

Mr. Charles Eleuterius
Gulf Coast Research Laboratory
P. O. Box AG
Ocean Springs, Mississippi 39564

Dr. Sayed Z. El-Sayed
Department of Oceanography
Texas A&M University
College Station, Texas 77843

Mr. Haven Emerson
Continental Shelf Associates
3650 West Bank Expressway
New Orleans, Louisiana 70058

Mr. Douglas Elvers
Bureau of Land Management
1001 Howard Avenue
The Plaza Towers
New Orleans, Louisiana 70113

Ms. Pamela Erickson
Department of Oceanography
Florida State University
Tallahassee, Florida 32306

Dr. Kent Fanning
Department of Marine Science
University of South Florida
St. Petersburg, Florida 33701

Mr. Robert N. Farragut
NOAA/NMFS
Southeast Fisheries Center
75 Virginia Beach Drive
Miami, Florida 33149

Dr. John W. Farrington
Woods Hole Oceanographic Institution
Woods Hole, Massachusetts 02543

Mr. Andrew Feinstein
Department of Marine Science
University of South Florida
830 First Street South
St. Petersburg, Florida 33701

Dr. Murray Felsher
Office of Technical Analysis
Environmental Protection Agency
Washington, D.C. 20460

Dr. John C. Ferguson
Eckerd College
Box 12560
St. Petersburg, Florida 33733

Dr. Edward Fernald
Department of Geography
Florida State University
Tallahassee, Florida 32306

Dr. Robert Flynn
Department of Physics
University of South Florida
Tampa, Florida 33620

Mr. Earl Ford
University of South Florida
429 6th Street South
St. Petersburg, Florida 33701

Mr. Thomas Frakes
Florida Department of Natural Res.
Marine Research Laboratory
100 Eighth Avenue S.E.
St. Petersburg, Florida 33701

Mr. Charles R. Futch
Florida Department of Natural Res.
Marine Research Laboratory
100 Eighth Avenue S.E.
St. Petersburg, Florida 33701

Ms. Rena S. Futch
Florida Department of Natural Res.
Marine Research Laboratory
100 Eighth Avenue S.E.
St. Petersburg, Florida 33701

Dr. Sherwood Gagliano
Coastal Environments, Inc.
1287 Main Street
Baton Rouge, Louisiana 70802

Dr. Robert W. Galbraith
University of Southern Mississippi
Box 5157, Southern Station
Hattiesburg, Mississippi 39401

Mr. Gene Gallaher
Department of Marine Science
University of South Florida
830 First Street South
St. Petersburg, Florida 33701

Mr. Louis Garrison
U. S. Geological Survey
P. O. Box 6732
Corpus Christi, Texas 78411

Dr. Stefan Gartner
Rosenstiel School
University of Miami
10 Rickenbacker Causeway
Miami, Florida 33149

Mr. Mike Gassaway
Sub Sea International
1600 Canal Street
New Orleans, Louisiana 70161

Mr. Len Gawel
Continental Oil Company
Box 1267
Ponca City, Oklahoma 74601

Dr. C. S. Giam
National Science Foundation
1800 G Street, N.W.
Washington, D.C. 20550

Mr. Brian Glass
Florida Department of Natural Res.
Marine Research Laboratory
100 Eighth Avenue S.E.
St. Petersburg, Florida 33701

Mr. Bob Gibson
Department of Marine Science
University of South Florida
830 First Street South
St. Petersburg, Florida 33701

Dr. Robert Ginsburg
Rosenstiel School
University of Miami
Fisher Island Station
Miami, Florida 33139

Mr. Mark F. Godcharles
Florida Department of Natural Res.
Marine Research Laboratory
100 Eighth Avenue S.E.
St. Petersburg, Florida 33731

Ms. Nancy Goldstein
Department of Marine Science
University of South Florida
St. Petersburg, Florida 33701

Mr. Mark E. Gorman
Department of Marine Science
University of South Florida
830 First Street South
St. Petersburg, Florida 33701

Dr. H. R. Gould
Esso Production Research Company
Box 2189
Houston, Texas 77001

Mr. G. A. Graves
National Science Foundation
1800 G Street, N.W.
Washington, D.C. 20550

Mr. Glen Greer
Department of Pollution Control
City of St. Petersburg
P.O. Box 2842
St. Petersburg, Florida 33731

Dr. George M. Griffin
Department of Geology
University of Florida
Gainesville, Florida 32611

Miss Lynn Griffin
Department of Biological Science
Florida State University
Tallahassee, Florida 32306

Mr. Charles J. Guice
Bureau of Land Management
3200 Plaza Towers
1001 Howard Avenue
New Orleans, Louisiana 70113

Mr. G. Gordon Guist
Department of Marine Science
University of South Florida
830 First Street South
St. Petersburg, Florida 33701

Mr. R. W. Hagood
Florida Department of Natural Res.
Marine Research Laboratory
100 Eighth Avenue S.E.
St. Petersburg, Florida 33701

Dr. John E. Hall
Department of Marine Archaeology
University of Miami
1867 Tigertail Avenue
Miami, Florida 33133

Dr. J. M. Hall
NOAA/ Data Buoy Office
Bay St. Louis, Mississippi 39520

Mr. John R. Hall
NMFS/ Gulf Coastal Fisheries Center
P.O. Box 4012
Panama City, Florida 32401

Mr. Kenneth R. Halscott
Florida Department of Natural Res.
Marine Research Laboratory
100 Eighth Avenue S.E.
St. Petersburg, Florida 33701

Mr. David Hamm
Department of Marine Science
University of South Florida
830 First Street South
St. Petersburg, Florida 33701

Dr. Donald V. Hansen
NOAA/AOML
15 Rickenbacker Causeway
Miami, Florida 33156

Mr. Keith Harris
University of South Florida
2108 John Moore Road
Brandon, Florida 33511

Mr. Keith Hay
American Petroleum Institute
1801 K Street N.W.
Washington, D.C. 20006

Mr. Gary Hayward
Department of Marine Science
University of South Florida
830 First Street South
St. Petersburg, Florida 33701

Mr. George Henderson
Florida Department of Natural Res.
Marine Research Laboratory
100 Eighth Avenue SE
St. Petersburg, Florida 33701

Mr. Donald Henninger
Bureau of Land Management
The Plaza Towers
1001 Howard Avenue
New Orleans, Louisiana 70113

Mr. Dannie A. Hensley
Department of Biology
University of South Florida
Tampa, Florida 33620

Dr. Allan Hirsch
NOAA - Ecosystems Analysis
6010 Executive Blvd.
Rockville, Maryland 20852

Mr. Bob J. Hoff
Decca Survey
8204 Westglen
Houston, Texas 73046

Mr. R. J. Hoagland
National Marine Fisheries Service
Duval Building
9450 Gandy Blvd.
St. Petersburg, Florida 33702

Mr. David R. Hopkins
Environmental Impact Statement Branch
Environmental Protection Agency
1421 Peachtree Street N.E.
Atlanta, Georgia 30309

Dr. Thomas L. Hopkins
Department of Marine Science
University of South Florida
830 First Street South
St. Petersburg, Florida 33701

Mr. Allan Horton
Sarasota Herald-Tribune
P.O. Box 1719
Sarasota, Florida 33578

Dr. Richard S. Houbrick
Smithsonian Institution
SOSC
Washington, D.C. 20560

Dr. Edward D. Houde
Rosenstiel School
University of Miami
10 Rickenbacker Causeway
Miami, Florida 33149

Dr. James D. Howard
Skidaway Institute of Oceanography
Skidaway Island, Georgia 31406

Dr. Wen H. Huang
Department of Geology
University of South Florida
Tampa, Florida 33620

Mr. Jack Hudson
Gulf South Research Institute
P. O. Box 1177
New Iberia, Louisiana 70560

Mr. James A. Huff
Florida Department of Natural Res.
Marine Research Laboratory
100 Eighth Avenue S.E.
St. Petersburg, Florida 33701

Dr. H. J. Humm
Department of Marine Science
University of South Florida
830 First St. South
St. Petersburg, Florida 33701

Mr. Curt Hutchinson
EG&G Environmental Engineering Serv.
196 Bearhill Road
Waltham, Massachusetts 02154

Mr. William Ingram
University of Florida Marine Lab.
1 Flint Hall
Gainesville, Florida 32611

Mr. Edwin W. Irby
Florida Department of Natural Res.
Marine Research Laboratory
100 Eighth Avenue S.E.
St. Petersburg, Florida 33701

Dr. Richard L. Iverson
Department of Oceanography
Florida State University
Tallahassee, Florida 32306

Mr. Walt Jaap
Florida Department of Natural Res.
Marine Research Laboratory
100 Eighth Avenue S.E.
St. Petersburg, Florida 33701

Mr. Joseph R. Jahoda
Bayshore Systems Corp.
5406A Port Royal Road
Springfield, Virginia 22151

Mr. Art Joens
Exxon
Box 60626
New Orleans, Louisiana 70160

Mr. Roger Johansson
University of South Florida
218½ 6th Avenue South
St. Petersburg, Florida 33701

Dr. David L. Johnson
Department of Chemistry
University of South Florida
Tampa, Florida 33620

Ms. Nancy J. Johnson
Environment Consultants, Inc.
14325 Proton
Dallas, Texas 75220

Dr. James I. Jones
Florida Coastal Coordinating Council
309 Magnolia Office Plaza
Tallahassee, Florida 32306

Mr. Lawrence T. Jones
Texaco, Inc.
P. O. Box 60252
New Orleans, Louisiana 70160

Dr. C. L. Jordan
Department of Meteorology
Florida State University
Tallahassee, Florida 32306

Mr. Edwin A.Joyce, Jr.
Florida Department of Natural Res.
Marine Research Laboratory
Larson Building
Tallahassee, Florida 32304

Mr. Rolf Juhl
National Marine Fisheries Service
P.O. Box 1207
Pascagoula, Mississippi 39567

Dr. George H. Keller
NOAA/AOML
Marine Geology & Geophysics Lab.
15 Rickenbacker Causeway
Miami, Florida 33149

Dr. Sheldon Kelman
Connell Associates
P.O. Box 677
Miami, Florida 33135

Mr. John Kendall
Department of Meteorology
Florida State University
Tallahassee, Florida 32306

Mr. Frank S. Kennedy, Jr.
Florida Department of Natural Res.
Marine Research Laboratory
100 8th Avenue S.E.
St. Petersburg, Florida 33701

Dr. Young Kim
Department of Chemistry
University of South Florida
Tampa, Florida 33620

Mr. Ronald H. Klausewitz
Department of Marine Science
University of South Florida
830 1st Street So.
St. Petersburg, Florida 33701

Dr. George A. Knauer
Biological Oceanography
Department of Oceanography
Florida State University
Tallahassee, Florida 32306

Dr. Harley J. Knebel
U. S. Geological Survey
Office of Marine Geology
Woods Hole, Massachusetts 02543

Mr. Francis A. Kohout
U. S. Geological Survey
National Center
Reston, Virginia 22092

Mr. Gerry Kolalinski
Department of Biological Science
Florida State University
Tallahassee, Florida 32306

Mr. C. B. Koons
Esso Production Research Company
P.O. Box 2189
Houston, Texas 77001

Dr. Henry Kritzler
Department of Oceanography
Florida State University
Tallahassee, Florida 32306

Mr. William C. Krueger
Amoco Production Company
P.O. Box 591
Tulsa, Oklahoma 74102

Mr. Curtis R. Kruer
Department of Marine Science
University of South Florida
830 First Street So.
St. Petersburg, Florida 33701

Dr. Herman E. Kumpf
NOAA/National Marine Fisheries Service
75 Virginia Beach Drive
Miami, Florida 33149

Mr. Edward C. Kutt
Department of Chemistry
University of South Florida
4202 Fowler Avenue
Tampa, Florida 33620

Dr. Paul LaRock
Department of Oceanography
Florida State University
Tallahassee, Florida 32306

Dr. John L. Laseter
Louisiana State University, NO
Lake Front
New Orleans, Louisiana 70122

Mr. David J. LeBlanc
Texaco, Inc.
P.O. Box 60252
New Orleans, Louisiana 70160

Dr. Jeffrey L. Lincer
Mote Marine Laboratory
9501 Blind Pass Road
Sarasota, Florida 33581

Mr. Ed Little
Florida Department of Natural Res.
Marine Research Laboratory
100 Eighth Avenue S.E.
St. Petersburg, Florida 33701

Dr. Robert J. Livingston
Department of Biological Science
Florida State University
Tallahassee, Florida 32306

Dr. J. Anthony Llewellyn
College of Engineering
ENG 118
University of South Florida
4202 Fowler Avenue
Tampa, Florida 33620

Mr. Lherif P. Lovaamm
Florida Department of Natural Res.
100 Eighth Avenue So.
St. Petersburg, Florida 33701

Mr. William G. Lyons
Florida Department of Natural Res.
Marine Research Laboratory
100 Eighth Avenue S. E.
St. Petersburg, Florida 33705

Dr. Julia S. Lytle
Gulf Coast Research Laboratory
P.O. Drawer AG
Ocean Springs, Mississippi 39564

Dr. Thomas Lytle
Gulf Coast Research Laboratory
P.O. Drawer AG
Ocean Springs, Mississippi 39564

Mr. Clayton McAuliffe
Chevron Oil Field Research Company
Box 446
LaHabra, California 90631

Mr. John C. McCarthy
Department of Marine Science
University of South Florida
830 First Street So.
St. Petersburg, Florida 33701

Mr. Scott McClelland
University of South Florida
830 First Street So.
St. Petersburg, Florida 33611

Dr. Andrew McErlean
U. S. Environmental Protection Agency
401 M Street, S.W.
Washington, D. C. 20460

Dr. Frank T. Manheim
Department of Marine Science
University of South Florida
830 First Street So.
St. Petersburg, Florida 33701

Ms. Wendy Manz
Nautilus Press
1056 National Press Building
Washington, D. C. 20004

Mr. William Martin
U.S. Coast Guard
P.O. Box 7944
Metairie, Louisiana 7011

Dr. Frank J. Maturo
University of Florida
Marine Laboratory
1 Flint Hall
Gainesville, Florida 32611

Mr. George A. Maul
NOAA/AOML
15 Rickenbacker Causeway
Miami, Florida 33149

Dr. Don Maurer
College of Marine Studies, Field Sta.
University of Delaware
Lewes, Delaware 19958

Mr. Ray Maurer
Department of Marine Science
University of South Florida
830 First Street South
St. Petersburg, Florida 33701

Ms. Val Maynard
Department of Marine Science
University of South Florida
830 First Street So.
St. Petersburg, Florida 33701

Mr. Roy Mays
Evening Independent
P.O. Box 1121
St. Petersburg, Florida 33711

Dr. Sylvia Earle Mead
Los Angeles County Museum
100 S. June Street
Los Angeles, California 90004

Mr. H. M. Meadow
Bolt Beranek & Newman, Inc.
8802 Daffodil Street
Houston, Texas 77042

Mr. John Meier
U. S. Department of the Interior
Bureau of Land Management
1001 Howard Avenue
The Plaza Tower
New Orleans, Louisiana 70113

Mr. Edward W. Mertens
Chevron Research Company
P.O. Box 1627
Richmond, California 94802

Ms. Renda Miller
Environment Consultants, Inc.
14325 Proton
Dallas, Texas 75280

Mr. Donald R. Millert
Limnetics, Inc.
6132 W. Fon du Lac Avenue
Milwaukee, Wisconsin 53225

Mr. Dean M. Milliken
Department of Marine Science
University of South Florida
830 First Street So.
St. Petersburg, Florida 33701

Mr. Jim Mims
Department of Geology
University of Florida
Gainesville, Florida 32601

Dr. Harold O. Mofjeld
NOAA/AOML
15 Rickenbacker Causeway
Miami, Florida 33149

Dr. Robert L. Molinari
NOAA/AOML
15 Rickenbacker Causeway
Miami, Florida 33149

Dr. Bruce F. Molnia
U. S. Department of the Interior
Bureau of Land Management
300 N. Los Angeles Street, Room 7663
Los Angeles, California 90012

Dr. Francis C. Monastero
U. S. Department of the Interior
Bureau of Land Management
Division of Marine Minerals (732)
Washington, D. C. 20240

Dr. C. N. K. Mooers
University of Miami
Rosenstiel School
10 Rickenbacker Causeway
Miami, Florida 33149

Mr. Stephen Moore
Department of Marine Science
University of South Florida
830 First Street So.
St. Petersburg, Florida 33701

Mr. Joe Mountain
Florida Department of Natural Res.
Marine Research Laboratory
100 Eighth Avenue S.E.
St. Petersburg, Florida 33701

Ms. Terrie Mueller
Department of Marine Science
University of South Florida
830 First Street So.
St. Petersburg, Florida 33701

Mr. Eugene L. Nakamura
NOAA/NMFS
Gulf Coastal Fisheries Center
P.O. Box 4218
Panama City, Florida 32401

Mr. Tony Natale
Environmental Consultants, Inc.
14350 Proton Road
Dallas, Texas 75240

Mr. Byron Nelson
Department of Pollution Control
City of St. Petersburg
P.O. Box 2842
St. Petersburg, Florida 33731

Mr. Sandy Nettles
Department of Geology
University of Florida
Floyd Hall
Gainesville, Florida 32601

Mr. Christopher Noe
NOAA/National Oceanographic Data Center
Environmental Data Service
Rockville, Maryland 20852

Mr. P. O'Brien
Coastal Engineering
University of Florida
450 C Weil Hall
Gainesville, Florida 32611

Mr. Robert V. Ochinero
NOAA/National Oceanographic Data Center
Environmental Data Service
Rockville, Maryland 20852

Professor Dennis M. O'Connor
University of Miami
Rosenstiel School
10 Rickenbacker Causeway
Miami, Florida 33149

Mr. Harold Odom
Odom Offshore Surveys, Inc.
8178 GSRI Avenue
P.O. Box 927
Baton Rouge, Louisiana 70821

Dr. Leroy Odum
Department of Geology
Florida State University
Tallahassee, Florida 32306

Mr. Larry H. Ogren
NOAA/NMFS
Gulf Coastal Fisheries Center
P.O. Box 4218
Panama City, Florida 32401

Mr. Erik Olsen
Florida Coastal Engineers
125 W. Church Street
Jacksonville, Florida 32202

Mr. C. D. Paget-Clarke
Decca Survey
8204 Westglen
Houston, Texas 77042

Mr. Thomas Palik
Department of Pollution Control
City of St. Petersburg
P.O. Box 2842
St. Petersburg, Florida 33731

Mr. Steven L. Palmer
University of South Florida
830 First Street South
St. Petersburg, Florida 33701

Dr. Patrick L. Parker
University of Texas
Marine Science Institute
Port Aransas, Texas 78373

Mr. Edward J. Pastula, Jr.
NOAA/NMFS/Fisheries Engineering Lab.
Mississippi Test Facility
Bay St. Louis, Mississippi 39520

Dr. Willis E. Pequegnat
Texas A&M University
Department of Oceanography
College Station, Texas 77843

Mr. Thomas H. Perkins
Florida Department of Natural Res.
Marine Research Laboratory
100 Eighth Avenue S.E.
St. Petersburg, Florida 33701

Mr. Allison Perry
Gulf Coast Research Laboratory
P.O. Drawer AG
Ocean Springs, Mississippi 39564

Mr. George F. Pessoney
University S. Mississippi
Box 18 S. Station
Hattiesburg, Mississippi 39401

Dr. Frank X. Phillips
Florida Department of Pollution Control
2562 Executive Center Circle E.
Montgomery Building
Tallahassee, Florida 32301

Dr. William B. Phillips
Science and Engineering
State University System of Florida
107 West Gaines Street
Tallahassee, Florida 32304

Mr. Mark J. Poff
Florida Department of Natural Res.
Marine Research Laboratory
100 Eighth Avenue S.E.
St. Petersburg, Florida 33704

Mr. Dion Powell
Florida Department of Natural Res.
100 Eighth Avenue S.E.
St. Petersburg, Florida 33701

Mr. Robert Presley
Department of Natural Resources
Marine Research Laboratory
100 Eighth Avenue S.E.
St. Petersburg, Florida 33701

Dr. Thomas E. Pyle
Department of Marine Science
University of South Florida
830 First Street So.
St. Petersburg, Florida 33701

Mr. Joe Quick
Department of Natural Resources
Marine Research Laboratory
100 Eighth Avenue S.E.
St. Petersburg, Florida 33701

Dr. William S.Richardson
Oceanographic Center
Nova University
8000 N. Ocean Drive
Dania, Florida 33004

LT. CDR. Larry Riley, USN
U. S. Navy - Oceanographic
200 Stovall Street
Alexandria, Virginia 22332

Mr. Murice O. Rinkel
State University System of Florida
Institute of Oceanography
830 First Street South
St. Petersburg, Florida 33701

Ms. Beverly Roberts
Florida Department of Natural Res.
Marine Research Laboratory
100 Eighth Avenue S. E.
St. Petersburg, Florida 33701

Mr. Bert Rodgers
U. S. Department of the Interior
Bureau of Land Management
Suite 3200 Plaza Tower
1001 Howard Avenue
New Orleans, Louisiana 70113

Mr. Scott W. Rogers
University of South Florida
830 First Street South
St. Petersburg, Florida 33701

Dr. Peter Rogerson
National Marine Water Control Lab.
Environmental Protection Agency
South Ferre Road
Narragansett, Rhode Island 02882

Mr. J. Kenneth Rolfes
Department of Marine Science
University of South Florida
830 First Street South
St. Petersburg, Florida 33701

Dr. James Roney
Dames & Moore
14 Commerce Drive
Cranford, New Jersey 07016

Dr. Bernard E. Ross
School of Engineering
University of South Florida
4202 Fowler Avenue
Tampa, Florida 33620

Mr. Stephen T. Ross
Department of Biology
University of South Florida
Tampa, Florida 33620

Mr. Paul Rowe
E G & G, Inc.
296 Lake Joyce Drive
Land O'Lakes, Florida 33539

Ms. Jennifer Sackett
Department of Natural Resources
Marine Research Laboratory
100 Eighth Avenue S. E.
St. Petersburg, Florida 33701

Dr. William Sackett
Department of Oceanography
Texas A & M University
College Station, Texas 78943

Mrs. R. Sample
Florida Wildlife Federation
200 Sunset Drive South
St. Petersburg, Florida 33707

Mr. Ranford Sapp
Westinghouse
Box 1488
Annapolis, Maryland 21404

Mr. Robert Schoen
U. S. Geological Survey
Stop 414, National Center
Reston, Virginia 22092

Mr. R. W. Schreiber
Department of Biology
University of South Florida
4202 Fowler Avenue
Tampa, Florida 33620

Mr. Palmer T. Schweppe
The Ocean Corporation
2120 Peckham
Houston, Texas 77019

Dr. William Seaman
Florida Sea Grant Program
G025 McCarty Hall
University of Florida
Gainesville, Florida 32601

Dr. D. A. Segar
NOAA/AOML
15 Rickenbacker Causeway
Miami, Florida 33149

Mr. A. H. Sellen
Florida Department of Natural Res.
Marine Research Laboratory
100 Eighth Avenue S. E.
St. Petersburg, Florida 33701

Dr. James M. Sharp
Gulf Universities Research Consortium
1611 Tremont Street
Galveston, Texas 77550

Mr. Randy Shaw
Department of Geology
University of South Florida
4202 Fowler Avenue
Tampa, Florida 33620

Dr. John W. Sheldon
Department of Physical Science
Florida International University
Tamiami Trail
Miami, Florida 33144

Mr. E. H. Shenton
TRIGOM
96 Falmouth Street
Portland, Maine 04103

Dr. Robert Sheridan
Department of Geology
University of Delaware
Newark, Delaware 19711

Mr. E. A. Shinn
Shell Oil Company
Environmental Affairs
One Shell Plaza
P. O. Box 2463
Houston, Texas 77001

Mr. James Sides
Hydrosurveys, Inc.
1532 Cordova Road
Ft. Lauderdale, Florida 33316

Dr. J. L. Simon
Department of Biology
University of South Florida
4202 Fowler Avenue
Tampa, Florida 33620

Mr. W. C. Sinclair
U. S. Geological Survey
500 Zack Street
Tampa, Florida 33602

Dr. S. C. Smeach
Department of Mathematics
University of South Florida
4202 Fowler Avenue
Tampa, Florida 33620

Mr. Gregory Smith
Florida Department of Natural Res.
Marine Research Laboratory
100 Eighth Avenue S. E.
St. Petersburg, Florida 33701

Mr. Paul F. Smith
E G & G Environmental Services
Woods Hole Institution
Woods Hole, Massachusetts 02543

Dr. Robert E. Smith
State University System of Florida
Institute of Oceanography
830 First Street South
St. Petersburg, Florida 33701

Dr. Philip Sorensen
Department of Economics
Florida State University
Tallahassee, Florida 32306

Mr. Dan Spangler
Department of Geology
University of South Florida
4202 Fowler Avenue
Tampa, Florida 33620

Mr. John Sprague
U. S. Department of the Interior
Bureau of Land Management
1129 20th Street N. W.
Washington, D. C. 20240

Mr. Lloyd E. Stahl
Dames & Moore
14 Commerce Drive
Cranford, New Jersey 07016

Mr. Steve Stancyk
University of Florida
Marine Laboratory
1 Flint Hall
Gainesville, Florida 32611

Mr. David L. Steed
Environment Consultants, Inc.
14325 Proton Road
Dallas, Texas 75240

Ms. Karen Steidinger
Florida Department of Natural Res.
Marine Research Laboratory
100 Eighth Avenue S. E.
St. Petersburg, Florida 33701

Mr. C. R. Stephan
Department of Ocean Engineering
Florida Atlantic University
Boca Raton, Florida 33432

Mr. Robert C. Stevens
Continental Shelf Associates
119 W. Beverly Road
Jupiter, Florida 33458

Dr. Harris B. Stewart, Jr.
Environmental Research Laboratories
NOAA/AOML
15 Rickenbacker Causeway
Miami, Florida 33149

Mr. Robert J. Stewart
M.I.T.
Cambridge, Massachusetts 02139

Mr. W. T. Storie, Jr.
Sun Oil Company
4151 Southwest Freeway
Houston, Texas 77027

Mr. John F. Studt
Department of Marine Science
University of South Florida
830 First Street South
St. Petersburg, Florida 33701

Dr. Wilton B. Sturges
Department of Oceanography
Florida State University
Tallahassee, Florida 32306

Mr. James R. Sullivan
Florida Department of Natural Res.
Marine Research Laboratory
100 Eighth Avenue S. E.
St. Petersburg, Florida 33701

Mr. John C. Sylvester
NOAA/National Oceanographic Data Center
15 Rickenbacker Causeway
Miami, Florida 33149

Dr. William H. Taft
Director of Sponsored Research
University of South Florida
4202 Fowler Avenue
Tampa, Florida 33620

Mr. Jack Tamul
Department of Oceanography
Florida State University
Tallahassee, Florida 32306

Dr. W. F. Tanner
Department of Geology
Florida State University
Tallahassee, Florida 32306

Mr. Bruce Taylor
Florida Coastal Engineers
125 West Church Street
Jacksonville, Florida 32202

Dr. John L. Taylor
1307 Pass-A-Grille Way
St. Petersburg, Florida 33706

Dr. William J. Tiffany
Environmental Studies Institute
New College
P. O. Box 1898
Sarasota, Florida 33578

Mr. W. H. Tolbert
U. S. Naval Coastal Systems Lab.
Code 773
Panama City, Florida 32401

Mr. B. E. Tucker
Sun Oil Company
4151 Southwest Freeway
Houston, Texas 77027

Dr. Joe W. Tyson
GURC
1611 Tremont Street
Galveston, Texas 77550

Mr. Jack van Breedveld
Florida Department of Natural Res.
Marine Research Laboratory
100 Eighth Avenue S. E.
St. Petersburg, Florida 33701

Dr. William L. Van Horn
U. S. Department of the Interior
Bureau of Land Management
1001 Howard Avenue, Plaza Tower
New Orleans, Louisiana 70113

Mr. Robert Vernon
Department of Natural Resources
Pennington Building
Tallahassee, Florida 32304

Dr. Roland von Huene
U. S. Geological Survey
National Headquarters
Reston, Virginia 22092

Mr. David W. Wallace
Department of Marine Science
University of South Florida
830 First Street South
St. Petersburg, Florida 33701

Dr. W. R. Walton
Amoco Production Company
P. O. Box 5340 A
Chicago, Illinois 60680

Dr. Harold R. Wanless
University of Miami
Rosenstiel School
10 Rickenbacker Causeway
Miami, Florida 33149

Mr. Robert E. Ward
E G & G Environmental Services
196 Bear Hill Road
Waltham, Massachusetts 02154

Mr. Jerry A. Watson
Geo-Marine, Inc.
777 South Central Expressway
Richardson, Texas 75080

Dr. G. L. Weatherly
Department of Oceanography
Florida State University
Tallahassee, Florida 32306

Ms. Linda S. Weinland
Department of Biology
University of South Florida
4202 Fowler Avenue
Tampa, Florida 33620

Mr. Fred Weiss
Shell Oil Company
3737 Bellaire Blvd.
Houston, Texas 77001

Mr. William R. Weiss
University of South Florida
830 First Street South
St. Petersburg, Florida 33701

Mr. Gordon Wells
Department of Biological Science
Florida State University
Tallahassee, Florida 32306

Dr. David C. White
Medical Sciences
Florida State University
Tallahassee, Florida 32306

Mr. Nick Whiting
Florida Department of Natural Res.
Marine Research Laboratory
100 Eighth Avenue S. E.
St. Petersburg, Florida 33701

Pre-Registered but Had Not Checked In Before the Registration Desk Closed

Dr. Mel Anderson
College of Engineering
University of South Florida
Tampa, Florida 33620

Dr. Thomas S. Austin
NOAA/NODC/EDS
Washington, D. C. 20852

Mr. Robert G. Ernest
Department of Marine Science
University of South Florida
830 First Street South
St. Petersburg, Florida 33701

Mr. Emil D. Hicks, Jr.
Department of Pollution Control
City of St. Petersburg
P. O. Box 2842
St. Petersburg, Florida 33731

Mr. Charles W. Holmes
U. S. Geological Survey
P. O. Box 6732
Corpus Christi, Texas 78411

Dr. Paul Lefcourt
E.P.A.
Waterside Mall
401 M Street, S. W., Room 3827
Washington, D. C. 20460

Mr. Paul V. LiCalsi
Federal Building
Lakeland, Florida 33801

Dr. James Marlowe
Dames & Moore
14 Commerce Drive
Cranford, New Jersey 07016

Dr. Hugh L. Popenoe
Florida Sea Grant Program
2001 McCarty Hall
University of Florida
Gainesville, Florida 32601

Dr. R. L. Raschke
E.P.A.
Bailey Road
Athens, Georgia 30601

Mr. George Register, III
Florida Coastal Engineers
125 West Church Street
Jacksonville, Florida 32202

Dr. George K. Reid
Eckerd College
P. O. Box 12560
St. Petersburg, Florida 33733

Mr. L. R. Rivas
NOAA/National Marine Fisheries Service
P. O. Box 4218
Panama City, Florida 32401

Dr. Eric C. Schneider
National Marine Water Control Laboratory
South Ferry Road
Narragansett, Rhode Island 02282

Dr. D. Keith Serafy
New York Ocean Science Laboratory
P. O. Drawer EE
Montauk, New York 11954

Dr. O. H. Shemdin
Coastal Engineering
University of Florida
Weil Hall
Gainesville, Florida 32611

Mr. George S. Smith
Mobil Oil Corporation
1001 Howard Avenue
New Orleans, Louisiana 70113

Mr. Clyde H. Stagner
Department of Pollution Control
City of St. Petersburg
P. O. Box 2842
St. Petersburg, Florida 33731

Mayor Randolph C. Wedding
City of St. Petersburg
P. O. Box 2842
St. Petersburg, Florida 33731

Dr. J. Ross Wilcox
The Harbor Branch Foundation Lab.
RFD 1, Box 196
Ft. Pierce, Florida 33450

Dr. Frank Williams
Rosenstiel School
University of Miami
10 Rickenbacker Causeway
Miami, Florida 33149

Mrs. Jean Williams
Florida Department of Natural Res.
Marine Research Laboratory
100 Eighth Avenue S. E.
St. Petersburg, Florida 33701

Mr. Scott Willis
Florida Department of Natural Res.
Marine Research Laboratory
100 Eighth Avenue S. E.
St. Petersburg, Florida 33701

Miss Karen Ann Wilson
Florida Power Corporation
P. O. Box 14042
St. Petersburg, Florida 33712

Dr. John W. Winchester
Department of Oceanography
Florida State University
Tallahassee, Florida 32306

Mr. Ken Winters
University of Texas
Box 604
Port Aransas, Texas 78373

Dr. Sherwood Wise
Department of Geology
Florida State University
Tallahassee, Florida 32306

Ms. Janet Witte
Nova University
8000 North Ocean Drive
Dania, Florida 33004

Ms. Charlene Womack
Continental Shelf Associates
3650 Westbank Expressway
New Orleans, Louisiana 70669

Dr. Robert Woodmansee
Gulf Coast Research Laboratory
P. O. Box A6
Ocean Springs, Mississippi 39564

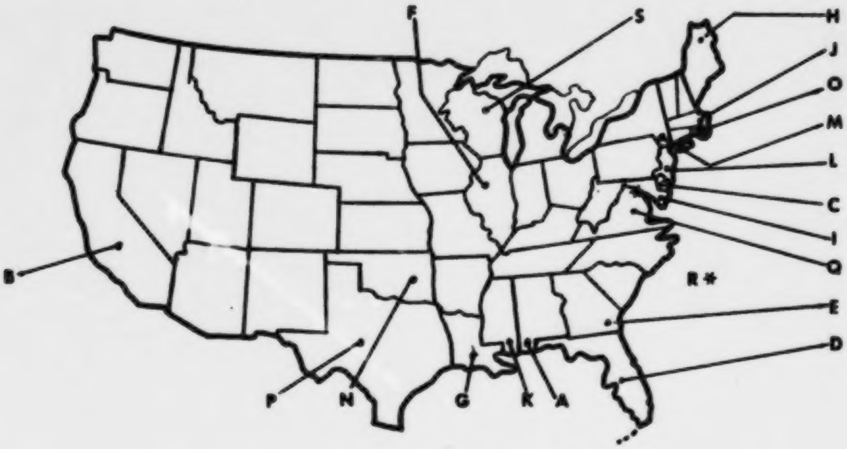
Mr. R. Yeiter
Bolt, Beranek & Newman, Inc.
50 Moulton Street
Cambridge, Massachusetts 02138

Mr. Paul P. Yevich
National Marine Water Quality Laboratory
P. O. Box 277
West Kingston, Rhode Island 02892

Mr. Robert Yockey
University of Florida
Marine Laboratory
1 Flint Hall
Gainesville, Florida 32611

Appendix VI

GEOGRAPHICAL LOCATIONS REPRESENTED AT CONFERENCE/WORKSHOPS



TOTAL REPRESENTATION - 352

A	
ALABAMA	
Dauphin Island	1
B	
CALIFORNIA	
LaHabra	1
Los Angeles	2
Richmond	1
C	
DELAWARE	
Lewes	1
Newark	1
D	
FLORIDA	
Boca Raton	1
Brandon	1
Clearwater	1
Dania	2
Ft. Lauderdale	1
Ft. Pierce	1
Gainesville	14
Jacksonville	3
Jupiter	1
Lakeland	1
Land O' Lakes	1
Melbourne	1
Miami	27
Panama City	5
Pensacola	4
St. Augustine	2
St. Petersburg	99
Sarasota	5
Tallahassee	36
Tampa	27
E	
GEORGIA	
Athens	1
Atlanta	1
Skidaway Island	1
F	
ILLINOIS	
Chicago	1
G	
LOUISIANA	
Baton Rouge	2
Lafayette	1
Metairie	1
New Iberia	1
New Orleans	19
H	
MAINE	
Portland	1
I	
MARYLAND	
Annapolis	1
Rockville	3
J	
MASSACHUSETTS	
Cambridge	2
Waltham	2
Woods Hole	3
K	
MISSISSIPPI	
Bay St. Louis	2
Hattiesburg	2
Ocean Springs	5
Pascagoula	1
L	
NEW JERSEY	
Cranford	4
M	
NEW YORK	
Montauk	3
N	
OKLAHOMA	
Ponca City	1
Tulsa	1
O	
RHODE ISLAND	
Narragansett	2
Portsmouth	1
West Kingston	1
P	
TEXAS	
College Station	8
Corpus Christi	2
Dallas	4
Galveston	2
Houston	11
Port Aransas	2
Richardson	1
Q	
VIRGINIA	
Alexandria	1
Reston	3
Springfield	2
R*	
WASHINGTON, D.C.	12
S	
WISCONSIN	
Milwaukee	1

GLOSSARY

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AECSOS	Alabama Estuarine and Continental Shelf Oceanographic Survey
AOML	Atlantic Oceanographic Meteorological Laboratories
API	American Petroleum Institute
ASTM	American Society for Testing Materials

BCF	Bureau of Commercial Fisheries
BLM	Bureau of Land Management
BOMEX	Barbados Oceanographic and Meteorological Experiment

CEDDA	Center for Experiment Design and Data Analysis
CICAR	Cooperative Investigations of the Caribbean and Adjacent Regions

DNR/MRL	Department of Natural Resources Marine Research Laboratory
DSRV	Deep Submergence Rescue Vehicle

EDBD	Environmental Data Base Directory
EDS	Environmental Data Service
EGMEX	Eastern Gulf of Mexico
ENDEX	Environmental Data Index
EPA	Environmental Protection Agency
NASA/ERL	Earth Resources Laboratory
ESCAROSA	Escambia - Santa Rosa Counties, Territorial seas of
ESIC	Environmental Science Information Center

FAA	Federal Aviation Administration
FAMU	Florida A & M University
FAU	Florida Atlantic University
FCCC	Florida Coastal Coordinating Council
FDNR/MRL	Florida Department of Natural Resources, Marine Research Laboratory
FGGE	First Global GARP Experiment
FICO	Florida Interinstitutional Committee on Oceanography
FIT	Florida Institute of Technology
FIU	Florida International University
FMG	Florida Middle Ground
FSU	Florida State University
FTU	Florida Technological University

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GARP	Global Atmospheric Research Program
GATE	Atlantic Tropical Experiment
GURC	Gulf Universities Research Consortium
IDOE	International Decade of Ocean Exploration
IFYGL	International Field Year for the Great Lakes
IGOSS	Integrated Global Ocean Station System
IOC	Intergovernmental Oceanographic Commission
LACM	Los Angeles County Museum
LOOP	Louisiana Offshore Oil Port
MAFLA	Mississippi-Alabama-Florida
MARMAP	Marine Monitoring and Assessment Program
MESA	Marine Ecosystem Analysis
MESC	Marine Environmental Sciences Consortium (Alabama)
MTS	Marine Technology Society
MUST	Manned Undersea Science and Technology
NAMDI	National Marine Data Inventory
NASA/ERL	Earth Resources Laboratory
NCC	National Climatic Center
NCSL	Naval Coastal Systems Laboratory
NGSDC	National Geophysical and Solar-Terrestrial Data Center
NMFS	National Marine Fisheries Service
NMFS/SFC	National Marine Fisheries Service/Southeast Fisheries Center
NOAA	National Oceanic and Atmospheric Administration
NODC	National Oceanographic Data Center
NODC/EDS	National Oceanographic Data Center/Environmental Data Service
NSF	National Science Foundation
NSF/IDOE	International Decade of Ocean Exploration
NU	Nova University
NYOSL	New York Ocean Science Laboratory
OCS	Outer Continental Shelf
OSF	Ocean Simulation Facility
OEI	Offshore Ecology Investigations
P.C.	Panama City, Florida
RFP	Request for Proposals
RSMAS	Rosenstiel School of Marine and Atmospheric Science, University of Miami

SFC	Southeast Fisheries Center
SITS	Scientist-In-The-Sea Program
STD	Salinity/Temperature/Depth Recorder
SUPSAL	U.S.Navy Superintendent of Salvage
SUSIO	State University System of Florida Institute of Oceanography
TAMU	Texas A & M University
UF	University of Florida
UNESCO	United Nations Education, Scientific, and Cultural Organization
UM	University of Miami
UNF	University of North Florida
USDI	U.S. Department of the Interior
USGS	U.S. Geological Survey
USF	University of South Florida
UTMSI	University of Texas Marine Science Institute
UWF	University of West Florida
WFGB	West Flower Garden Bank
WHOI	Woods Hole Oceanographic Institution
XBT	Expendable Bathythermograph

90° W
40° N
95° W
35° N
30° N
100° W
GULF COASTAL PLAIN